TIMBR-1: Timber Products Supply and Demand

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What are the history, status and projected future demands for and supplies of wood products in the South?

1 Key Findings

- The South produces approximately 60 percent of the nation's timber products, almost all of it from private forests; the South produces more timber than any other single country in the world, and it is projected to remain the dominant producing region for many decades to come.

- Timberland area is projected to increase in many parts of the South, especially in western and northern portions, due to agricultural land conversion to forest and to tree planting. Timberland will be lost, especially to urban and residential land uses and especially in the Piedmont region (Virginia to Georgia) and in Florida. The net effect of losses and gains is no significant change in timberland area under two plausible scenarios. However, in aggregate in the South, nonplantation forest acreage is projected to decline by an average of 15 percent under all market and plantation growth scenarios considered.

- Production of both hardwood and softwood timber is projected to increase southwide, but the largest percentage increases are projected for northern and western portions of the region, especially in Alabama, Arkansas, Kentucky, Tennessee, and Virginia.

- Timber prices are projected to increase in the United States and the South over the next 40 years under two plausible scenarios. The price rises serve as continued incentives for private forestland owners to keep land in forests in some places, to improve timber growing and wood processing productivity, and to heavily invest in timber growing technology and intensive forest management.

- Private landowners in the South are projected to continuously expand areas of pine plantations in the region far into the future. An outcome of this is a projected increase in the area of pine plantations--in the base scenario, by 67 percent (from 33 to 54 million acres) between 1995 and 2040.

2 Introduction

This Chapter describes historic, current, and projected timber inventories and timber product outputs from southern forests. It also attempts to place these quantities in national and international perspectives. Timber is the most valuable commercial commodity taken from most forests, and its removal strongly influences the character of those forests. Timber is removed to convert land to other uses, and it is removed in regular harvests activities of managed forests. These two processes do not occur randomly on the landscape. Rather, they occur in patterns that are predictable, related to the locations of development, timber processing capacities, and the species in demand for timber products. Because removals are a function of societal demands, the products made from timber, and the technologies used to remove and process timber, the nature of forests and projected future of those forests can be traced out by relating economic and demographic trends to the timber products sector. The economic and demographic relationships to the timber sector can be identified through a description of historical patterns of timber production and technologies. Hence, such a description provides substantial information for predicting the future of southern forests.

In describing the history and projected future of southern forests and their associated timber markets, technical terminology is often used. For clarity, it is worth defining some frequently used terms. Demand is the schedule of quantities that would be purchased by consumers over a range of prices. Supply is the schedule of quantities that would be produced in a geographic region by product manufacturers over a range of prices. Production is defined as the amount that is actually produced in a geographic region, and consumption is how much is actually purchased by consumers in a geographic region. If a country or a state consumes more than it produces of a given product, then it is a net importer of that product. If it produces more than it consumes, then it is a net exporter. The incentive for a country or state to produce a different quantity from what it consumes arises out of the ability of buyers and sellers to move products back and forth across national borders and state lines profitably.

To address questions of historical and future supplies and demands for timber products, six steps were taken:

- Historical production levels were described for the South's major species groups and timber products, including pulpwood, sawtimber, residues, fuelwood, and other fiber products. Southern production was sometimes contrasted with similar production occurring elsewhere in the country.

- The linkages to international markets were evaluated, and implications of changing wood products exports and imports of competing materials were considered.

- Market linkages with other parts of the United States were evaluated.

- Projections of future timberland areas by major forest types, timber inventories, timber growth, timber removals (production), and timber prices were made under a base scenario of supply and demand assumptions and under three alternative scenarios. Projections for the South were put into additional context with the rest of the nation and the world by reporting some findings of the 2000 Draft Resources Planning Act Assessment (Haynes and others 2001).

- Possible effects of land-use change on timber supplies were evaluated.

- The impacts of changes in intensity of forest management and in forest productivity on timber supply and forest composition were described.

Data and space limitations constrained the extent and detail of information to provide. The Chapter does not describe every issue of historical, current, or potential future importance for the South's forests. Further, a lack of data on historical production and consumption patterns limited opportunities to describe and draw conclusions about some important trends and relationships. The primary sources of data for the Chapter are given, however, for those who wish to pursue certain issues in detail. Similarly, the methods of analysis are outlined rather than explained in detail. Details are to be found in the cited literature. Finally, those interested in broader, national projections and details about other regions of the United States, are directed to the 2000 RPA Assessment (Haynes and others 2001).

As in the rest of this Assessment, this chapter does not evaluate policies or make policy recommendations. Those interested in conducting these kinds of analyses, however, may find the material presented here to be useful starting points.

3 Methods

Much of this Chapter is concerned with projections of the future. Because projecting the future is controversial and complex and always subject to great uncertainties, some explanation of projection procedures is warranted. Trends in the southern timber sector were projected with a partial equilibrium model of the southern forest sector, the Subregional Timber Supply Model (SRTS) of Abt and others (2000). SRTS provides projections of timber inventories, growth, removals, prices, land use, and timberland area by five broad forest management types at sub-State and Ecoregion (Bailey 1995) levels. The SRTS projections are based on the results of empirical models of timber and land supply and demand relations to prices, income, and other variables. The projection period for this Assessment had a starting point of 1995 and an ending point of 2040.

SRTS consists of four models Figure 1: (1) a timber inventory model, which projects each year's softwood (coniferous) and hardwood (non-coniferous) timber growth (net after mortality) on existing acres, based on a set of growth equations and on the previous year's harvests of softwood and hardwood; (2) a stumpage market model consisting of supply and demand curves for timber softwood and hardwood timber harvests, which determines the amount of harvests, the timber prices, and the volume and the state of the inventory in softwood and hardwood; (3) a pine plantation allocation model, which determines, how many acres of pine trees to plant, given the softwood price and other factors: and (4) a timberland allocation model, which determines how much land is devoted to forest, given timber prices, financial returns to agricultural land uses, and other factors. For each year of the projection, SRTS solves for the combination of southwide softwood and hardwood timber prices, softwood and hardwood timber harvests, pine tree planting acres, and total forest area that makes the supply of timber equal its demand. Although land-use is projected at the county level, the precision of historical inventory and harvest data limits the smallest unit of inference for the projected variables in the model to the USDA Forest Service Forest Inventory and Analysis (FIA) Survey Unit.

The primary outputs of the model are annual values of: (1) timberland area by five forest management types (pine plantation, natural pine, mixed oak-pine, upland hardwood, bottomland hardwood) by Survey Unit; (2) a single volume measure of timber growth, removals, and inventory by management type, Survey Unit, and owner; and (3) indices of southwide aggregate softwood and hardwood timber prices. Because these projected variables are outcomes of the model, they may all be termed "endogenous" (that is, determined by the model). Two exceptions on the endogeneity of land use were Kentucky after 2020 and Oklahoma for the entire projection period. Data limitations permitted projections of Kentucky's land-use allocation only through 2020, but remained fixed thereafter. Oklahoma did not have an applicable land-use model, so that portion of Oklahoma that was included in this Assessment had land use (and, hence, forest areas by owner and survey unit) fixed at observed 1993 levels during the entire projection period.

SRTS has several "exogenous" inputs--pre-specified model parameters and the levels and trends of certain variables that set the context of the model solution. While the model parameters, which quantify the relationships among endogenous and exogenous variables, are held constant, alternative levels of some of the exogenous variables and some model parameters collectively define four projection scenarios (Table 1). One exogenous variable is timber demand growth over time, a forecast of how the demand curves for hardwood and softwood timber shift each year. This was specified as a 1.6 percent annual expansion in demand. The rate of annual timber demand growth was based on historical trends and historical relationships between population growth, technological change, and timber product consumption patterns. Also, this growth rate is roughly the same as that specified for the South in the Draft RPA 2000 Assessment. The exogenous determination of timber demand growth implies that the model takes the rest of the world as given, so that the model does not feed back to other regions when calculating its annual combinations of forestland acres by management type, timber harvest volumes, and prices. The exogenous determination of demand growth therefore does not allow southern timber prices to induce technology changes in the product manufacturing sector, nor does it allow timber prices to directly affect the rate of substitution of other raw materials or non-southern virgin wood fiber for southern virgin wood fiber in forest product manufacturing, except to the extent that the historical rate of timber demand growth embodies the historical rate of product substitutions and technology changes. An accounting for those kinds of feedbacks might be justified if the South were a small region compared to the rest of the country (or if model complexity were unrelated to model accuracy). However, the South dominates the U.S. timber market, so the exogenous demand growth determination can be viewed as a reasonable approximation of true national market functions.

Also predetermined prior to solving the SRTS model for the 45 years of projection is a set of variables involved in the land-use allocations. These variables include projections of population growth, aggregate U.S. economic growth, agricultural rents (the real annual monetary returns to using land to produce an agricultural output), and residential land rents (see SOCIO-5 for a more detailed discussion of the land use module). Agricultural rents were specified as constant (in real terms) over the entire projection period. Another key exogenously determined variable in the SRTS projection is the rate of increase in the growth rate of pine plantations in the South. Underlying projection parameters and inputs used in the SRTS model projections for the South are shown in Table 1.

Although four scenarios were modeled in this Assessment, one, abbreviated “IH” for “inelastic demand-high plantation growth rate increase,” is designated as the “base case” for two reasons. First, the inelastic demand assumption is consistent with empirical findings of responses of demand to prices and is consistent with assumptions of RPA projections. Second, the SRTS model authors determined, through informal surveys of industry and pine plantation experts in the South, that the higher plantation volume growth rate increases (75 percent for industry plantations and 37.5 percent for nonindustrial private plantations) are closest to a lower bound on plantation growth rate increases expected over the period. These alternative scenarios were performed to demonstrate the marginal effects of plantation growth rates and timber demand elasticities on important model outputs. Results from the Base Case scenario are discussed first. Some of the results are contrasted with results for the other scenarios, and figures describing the results of other scenarios are also made available to the reader.

As with many forecasting models, an underlying assumption in SRTS for this Assessment is that timber supply and demand and land use supply and demand relationships remain stable. In that sense, the projections do not account for changes in the share of the "available" or harvestable timber out of all timberlands owned by various owner categories (including government, industry, or nonindustrial private). Neither do the projections incorporate any predicted changes in wood product substitutes, wood product manufacturing technologies, real costs of timber management or production, or consumer tastes and preferences. Finally, the projections do not incorporate the effects of any expected changes in industrial structure in the paper or other industries. To the extent that such structural changes in these sectors affect assumed underlying supply and demand parameters, our projections are inappropriate. When interpreting the projections reported in this Chapter and projections reported elsewhere, it is important to consider that projections and their underlying assumptions about economic variables become less and less reliable as the length of the projection increases.

SRTS has been designed to describe projections of the future for small regions or specific parts of the South. The Forest Inventory and Analysis Survey Unit boundaries divide each Southern State into three to six sections, whose boundaries follow county lines but generally divide the States into physiographic regions. An advance of SRTS from the projections provided in Abt and Others (2000) is that this version of SRTS now permits reporting of outputs by spatial units called "Ecological Regions" (Bailey 1995), which are not associated with political boundaries. As it turns out, Ecological Region boundaries follow Survey Unit boundaries fairly closely, as both division structures are based on many of the same factors. Given this, little of what is reported in this Chapter actually is described in the context of Ecological Regions, though the data outputs could be reorganized in that fashion.

4 Data Sources

Data on international trade in timber products were obtained from the United Nations Food and Agricultural Organization (2000a). Historical National Forest timber harvest data were obtained directly from the National Forest System’s fourth quarter annual totals in the "Cut and Sold" reports (USDA Forest Service 2000). National level historical harvest and wood use and productivity information was provided by the Forest Products Laboratory (Kenneth Skog and Peter Ince, personal communication) and from supporting documents (Ince 2000). Pulpwood production data for the South are from Johnson (1996), Johnson and Howell (1996), and Johnson and Steppleton (1996, 1997, 1999, 2000). Removals data by type of product were provided by the USDA Forest Service (1958, 1982), Hair (1963), Phelps (1980), Waddell and others (1989), Powell and others (1994), and Haynes and others (2001). Draft 2000 RPA projection information was obtained from Haynes and others (2001).

Input data for all SRTS projection scenarios derived from the plot-level data from the latest Forest Inventory and Analysis surveys for each state in the South. The Southern Research Station of the USDA Forest Service, Asheville, NC, was the source of those raw data. Inventory growth rates, mortality rates, and the starting points of inventory volumes used in the projections were calculated from these data

5 Results

5.1 History and Current Status of Timber and Timber Product Supply and Demand

5.1.1 World Demand and Supply History and Status

The United States is the largest producer of industrial timber in the world. For the last 40 years, it has produced a fairly stable 25 percent of total world production of industrial roundwood (United Nations Food and Agricultural Organization 2000b). In 1999, the world produced about 53.2 billion cubic feet (bcf), while the United States produced 15.1 bcf, or 28.5 percent of the total. The second largest producer, Canada, produced about 12 percent (6.4 bcf) of the industrial roundwood in 1999. In order, the next most important were China (3.6 bcf), Brazil (1.9 bcf), Sweden (1.9 bcf), and Finland (1.8 bcf).

Although these countries are major producers, domestic demands in those counties greatly influence their stature in international markets for timber products. Observed trade flows in wood and paper products worldwide (Table 2) can largely be ascribed to differences among countries in size of demand, amount of forest, and distance between trading partners (Bonnefoi and Buongiorno 1990). Besides these fundamental factors, trade is affected by government policies such as tariffs and nontariff barriers. Timber products trade also seems to be related to historical political relationships (Castillo and Laarman 1984).

The large size of the United States forest resource helps to determine why the country produces so much, while the size of its domestic economy helps explain why it imports so much. How much a country imports and exports is determined by whether the country's domestic manufacturers supply more than the country's domestic consumers demand at current prices. Countries with reasonably free trade typically do not demand exactly what domestic producers supply. Thus, although the United States because of its extensive forest resources is the world's biggest producer and second largest exporter, after Canada, the relatively free flow of imports, large population, and high per-capita income enables the United States to be the world's largest timber product importer. To illustrate, in the past decade and in terms of dollar value, the United States imported 60 percent more timber products than it exported.

The costs of product movement are why the distance between markets plays a role in determining both the scale of trade and specific trading partners. Usually, the closer physically that two trading partners are, the lower the transport cost. Canada and the United States possess the largest bilateral trade flow, partly because the two countries have a long common border. Proximity also explains partly why virtually every country south of the United States border counts the United States as both its primary source of timber product imports and its principal destination of timber products exports. In Asia and Europe, the dominant trade flow is from nearby Asian supply sources (Indonesia, Malaysia, New Zealand, and Russia) to nearby demand centers.

Both the volume and value of timber products trade have been growing rapidly worldwide, and so trade is becoming more important in many countries as an influence on their forest sectors. Rapid trade growth can be ascribed both to overall world economic growth and to decreasing barriers to international trade. Tariffs on timber products have been decreasing worldwide, as a result of consecutive rounds of the General Agreement on Tariffs and Trade (GATT) and World Trade Organization (WTO) (Barbier 1996).

The United States trades in all kinds of timber products. In terms of value, the most important exports are wood pulp, printing and writing paper, and hardwood lumber. United States exports go predominantly to Europe, Canada, Japan, Mexico, the rest of Latin America, and the Caribbean. The most important imports are softwood lumber, newsprint, printing and writing paper, and wood-based panels. Nearly all of United States imports of softwood lumber, panels, and newsprint are from Canada. The United States has negotiated through the General Agreement on Tariffs and Trade (now the World Trade Organization) and other bilateral and multilateral accords some of the lowest barriers to forest products imports in the world. These accords have helped to ensure that U.S. barriers to timber product imports are kept low, probably facilitating the import into this country of wood fiber from emerging producers such as Brazil and Chile. These same accords, however, have also boosted timber product exports to many of those same countries. Recent trade agreements (The Canada-U.S. Free Trade Agreement (CUSTA) and the North American Free Trade Agreement (NAFTA)) have reduced many barriers to trade between these two trading partners, but some disputes have long simmered over softwood lumber and other product exports to the United States. Because the United States is a net timber product importer, then, these lower barriers may have served to reduce returns to timber growing and timber product manufacture in the United States. For example, a growing trend has been the importation of hardwood fiber into the United States from Latin America, especially Brazil. So far, these imports are relatively small, but a possible result of this trend, should it continue, would be to dampen prices below what they would be without such fiber imports. Nevertheless, the trade liberalization agreements, including NAFTA, CUSTA, and WTO-sponsored rounds of barrier reductions, tend to increase aggregate timber product output in the long run and to increase exports of U.S. wood products (e.g., Prestemon and Buongiorno 1996), benefiting American timber producers. The net effects of trade liberalization on the entire U.S. timber-based sector, therefore, are probably small (Barbier 1996, Trømborg and others 2000).

Southern timber products of importance in trade include southern pine (*Pinus* spp.) lumber, hardwood lumber (especially oak, *Quercus* spp.), southern pine plywood, kraft pulp, and kraft-based paper (packaging and paperboard). The principal destinations for these products are Western Europe, Latin America, and the Caribbean. Because the population and economies of the latter two regions are growing quickly, demand there for southern timber products exports also can be expected to rise rapidly. Asian countries for the most part have not been major purchasers of southern products (one exception is hardwood chips, going primarily to Japan), so the effect of that region's growth in population and wealth, should long-term trends continue, would be to increase timber product prices in the United States and Canada.

5.1.2 United States Supply and Demand History and Status

Demand for timber products in the United States has shifted among regions continuously since the 1800s. Settlement in the East, Upper Midwest, Interior West, and the Far West was often preceded and facilitated by harvests of old-growth forests. In the East, virtually all of the forests were harvested in the process of land cover conversion to agriculture, but some forests were allowed to grow back. This process was repeated as European settlement moved westward over the ensuing decades. The final stages of old-growth forest liquidation happened in the Pacific Northwest in the last century; the remaining portion is largely protected by reserves, parks, and government policies adopted in the late 1980s and 1990s.

National forest harvests have changed markedly since 1950 (Figure 2). In that year, their share of the United States harvests was 6.6 percent. By 1964, it was 17.5 percent. But by 1998, the share had dropped, this time to 3.5 percent, a result of desires to preserve remaining old-growth forests in the West, to protect habitats of endangered species, and to limit clearcutting. Except for the Southern Region, harvests have declined since 1990 to small fractions of harvests observed in the mid-1980s (Figure 3). The largest percentage drop in harvests was in the West, notably the Pacific Northwest. Its share in total United States harvests declined from a 1950-1989 average of 5.8 percent of all harvests to 0.7 percent of all harvests in 1998.

End uses for harvested wood have evolved over the years, with the mix of uses moving from solid wood outputs, such as lumber, to a greater share of composite products, such as particleboard and paper. As a result, the amount of timber being processed into wood chips, nonwood materials, and recycled fiber has been increasing (Figure 4). The increased use of recycled fiber and other fiber and product substitutes shown in Figure 4 can explain part, but not all, of the decline in timber harvests in the United States since the early 1990s. Another major factor is the steady rise in net product imports. Third has been the increasingly complete utilization of wood in manufacturing processes (Figure 5) (Ince 2000), which would compensate for some of the steadily rising demand for timber products that has been observed in recent decades. Wood use efficiency rose 41 percent from 1952 to 1998. Wood use efficiency was 9 percent higher in 1998 than in 1990, which can also account for much of the reduction in the observed timber product output of the past few years.

5.1.3 Southern Supply and Demand History and Status

Southern States produce most of America's industrial wood output, and their share has grown steadily since the 1960s (Figure 6). The South produced 41 percent of the country's wood fiber output in 1952 and 58 percent in 1997. Over the same period, the South's share of the world's industrial wood production rose from 6.3 to 15.8 percent. Meanwhile, the Pacific Northwest's share of the country's production dropped from 24.8 to 16 percent.

In terms of timber value, the South's role in production has grown steadily since the 1960s, as well. In other regions of the United States, this share has been less stable (Figure 7). As a result, the timber product sector has been a more constant source of economic output in the South compared to other regions. Further, such a steady increase in output implies that investment opportunities for intensive forest management and product manufacture have improved in the South relative to other regions (Murray and Wear 1998, Guan and Munn 2000).

Over the last 50 years, the relative desirability of western and southern timber products has changed. Earlier in that period, western conifers, which dominated much of the timber product market, were considered ideal in construction framing and sheathing, and in pulp. Spruce (*Picea* spp.), fir (*Abies* spp.), Douglas-fir (*Pseudotsuga menziesii* Franco.), western hemlock (*Tsuga heterophylla* (Rafn.) Sarg.), and western pines make excellent framing lumber and plywood because of their lightness (low density), strength, stability, and workability. Southern pine, on the other hand, historically was not as desired as western and northern softwoods in construction applications. As timber product manufacturing technology for southern pine advanced, however, southern pine's desirability in national construction markets improved. Until the 1960s, the technology for producing southern pine plywood with desirable characteristics for construction that could compete directly with western plywood did not exist. Similarly, until the 1980s, when old-growth rot-resistant woods such as redwood and western redcedar became scarce and before chemical treating technology for southern pine was perfected, treated southern pine lumber was not as desirable for outdoor applications such as decking. Since then, treated southern pine has supplanted these western woods for much of the outdoor application market.

Western manufacturers of strong, long-fiber pulp and paper rely largely on residues from coniferous wood products manufacture--slabs, shavings, and trimmed edges. Therefore, the softwood sawtimber harvest reductions in the West in the 1980s and 1990s have been accompanied by reduced output of pulpwood. Nationally, pulp and paper manufacturing has become more reliant on sources other than western conifers. Southern pine fibers are ideal for high-strength pulp (especially kraft pulp), so pulp and paper manufacturing has become more dependent on pulpwood production in the South as paper demand has grown and western timber production has waned. The rise in the output and technological advancements in structural and nonstructural wood panels and other engineered wood products have created new demands for smaller diameter and lower quality hardwood and softwood timber.

Without increased investment in the forest sector, production contraction in one part of the country, such as recently observed in the Pacific Northwest, inevitably leads to rising timber prices, rising imports, shifts in demand away from wood-based and toward nonwood product substitutes, and the development of new and more efficient manufacturing technologies. In response to price rises, increases in wood product imports, and product substitutions (Figure 4), product manufacturers in the United States, the South, and elsewhere have enhanced wood-use efficiency (Figure 5).

Other responses to changing technologies and price increases have been new and rapidly rising rates of investments by landowners in the South in pine-growing technology. This technology has two parts: (1) intensive cultivation, including tree planting, thinning, fertilization, and vegetation management; and (2) genetic improvement. An index of southern investments in tree growing technology is the rate of tree planting (Figure 8). The trend in such planting has been upward since 1945, with two sharp peaks since that time. The peaks were created in part by incentives programs, including the Soil Bank and Conservation Reserve Programs. Although some of the planting is on newly harvested plantations themselves, part of it is on land previously used for agriculture and part on land previously covered by natural forest types. Both kinds of planting are indicative of how producers have sustained or increased their investments in timber management. The net effect of those investments has been a rising share of pine plantations in the total forest area in the South.

In spite of rising pulpwood production and improvements in product manufacturing efficiency, producers have not been able to increase output as fast as the economy's demands for pulp-based products have grown. As a result, pulpwood prices (adjusted for inflation) have risen (Figure 9). In 1953, virtually no residues (wood chips and other wastes) were used in wood products manufactured in the South; panel and pulp production was made from roundwood. By 1998, residues accounted for over half of the volume of both softwood and hardwood fiber received at the gates of pulpmills and composite panel mills. Given the price rise along with the production increase, it is apparent that technological change and the economic advantages provided by the technology have not been enough to keep prices from rising in real terms. Still, these steadily rising prices serve as incentives for consumers of pulpwood and producers of pulpwood to invest in efficiency-enhancing technologies.

Another important trend that has arisen out of changing technologies and increasing prices has been the rising share of hardwood in southern timber production. For example, in 1953, hardwood roundwood was about 12 percent of all roundwood removed, while in 1999, hardwood roundwood was 34 percent. Hardwood roundwood nearly tripled in output while softwood roundwood slightly more than doubled. Price changes reflect this: hardwood roundwood prices have increased by two-thirds in real terms over the period, while softwood prices have increased by about 15 percent.

Another way that producers of timber products in the South have adapted to rising demands, increasingly competitive substitute products and imports, and rising prices is by altering timber processing. One change in recent years is the chipping of wood at satellite locations. This process is controversial because it encourages harvesting in areas not previously subject to harvesting and encouraging clearcutting, especially of natural management types that before were harvested in a different way. Many view this as negative. Others have viewed the technology positively, creating conditions for better forest management because the chipping technology discourages incomplete or high-graded harvests and because it provides additional income to owners of lower-quality timber. Before the 1990s, pulpmills and manufactured wood panel mills relied heavily on remote log concentration yards and maintained large chipping facilities at the site of panel and pulp manufacture. Today pulpwood-sized logs increasingly are chipped away from the mill, and are brought to the mill as needed. Per unit of volume, moving wood in chipped form is cheaper than moving pulp logs (Dodrill and Cubbage 2000), providing a significant economic benefit to pulpwood consumers and log producers. The current distribution of these remote or "stand-alone" chip mills is shown with the locations of other kinds of chipping facilities in Figure 10. The buyers of most of these chips, pulpmills and manufactured panel mills, are shown along with miscellaneous other mills in Figure 11. A small portion of these chips also derives from a few of the thousands of southern sawmills (Figure 12).

The majority of chips produced in the South are used to make paper and composite wood panels. In 1998, there were 159 chip mills (Prestemon and others 2001), but by 2000, 146 were found in the South. More than three quarters of all chip mills were stand-alone in 2000, not directly tied to a particular wood processing plant; most of the remainder were tied to a pulp mill. Chip mills processed about 27 percent of the pulpwood in the South in 1999 (Hyldahl and others 2000). They produced 47 million green tons of chips in 1998, 45 million green tons in 1999, and 39 million green tons in 2000. In 1999, approximately 42 percent was softwood and 58 percent was hardwood.

Not all of the wood chips produced in the South are consumed by U.S. mills (Figure 13). Since 1989, increasing amounts of wood chips have been exported from the United States. Between 1989 and 1999, residue exports from Southern ports increased 369 percent for hardwood and 372 percent for softwood. Because most residues today are in the form of wood chips, we can say that the export share of southern hardwood residue production increased from 12 percent in 1989 to 39 percent in 1999, while the export share of southern softwood residue production increased from 0.3 to 1.3 percent between those years (U. S. Department of Commerce 2000). Hardwood and softwood wood residue production comprised approximately 12 percent of all wood fiber production in the South in 1996, the latest year for which data are available.

Another indicator of the effect of changing wood production and manufacturing technology is the rising importance of more highly manufactured timber products. Apparently there is a trend toward concentrating a higher proportion of value added at the point of initial manufacturing. Since the 1950s, the use of wood for fuel, posts, poles, and pilings has declined, in favor of wood produced for lumber, paper, and engineered wood products (Figure 14). The proportion of output going to fuelwood in the 1950s was over 20 percent; it has since dropped to under 3 percent. The share of output dedicated to the category of "other product removals"--primarily for posts, poles, pilings, and composite products--has fallen by two-thirds, settling today at about 2.5 percent of timber product output in the South. Between 1954 and 1996, the percentage of wood removed as sawlogs was nearly constant, at around 38 percent. Pulpwood's share rose from 21 percent in 1952 to 47 percent in 1972 and has since leveled off at around 40 percent. The proportion of output in the form of the largest and highest quality logs, veneer logs, has trended upward, from 3 percent in 1952 to about 9 percent in the 1990s. Hence, in contrast to the trend toward more wood products derived from chipped material, the importance of sawmills, especially those manufacturing hardwood lumber and veneer, has risen or been maintained. In the South, the largest number of hardwood sawmills is in areas where hardwood production is most dominant: mountainous portions of Virginia, North Carolina, and Tennessee (Figure 12). But overall production of hardwood timber is highest in Mississippi, North Carolina, Georgia, Alabama, and Virginia.

5.2 Projections of Timber and Timber Product Supply and Demand

Supplies of and demands for timber products in the South will depend heavily on national and world trends. Southern supplies and demands through 2040 were projected with the SRTS model, with national and international trends taken as given. What follows is a discussion of some of the world and national projections from the literature plus a description of how SRTS projects what will happen in the South in the coming decades.

5.2.1 World Supply and Demand Projections

World timber production is expected to rise steadily well into the 21st century. Projections by Trømborg and others (2000) show that timber production will increase by 1.2 percent per year through 2010, with likely continued increases beyond that year. Their analysis also projects: (1) that U. S. growth in production will be 0.4 percent, implying that the United States will remain a timber product importer; (2) that the U.S. share of exports on world markets may decline; and (3) that U.S. imports will rise. The United States experienced an average compound annual growth rate for timber products output of 1.4 percent from 1961-1999, so this lower rate of 0.4 percent appears to be a substantial departure from the past but closer to the realized compound annual growth rate since 1990, which has been essentially nil (0.04 percent).

5.2.2 United States Supply and Demand Projections: RPA

The Draft Forest and Rangeland Resources Planning Act (RPA) Assessment (Haynes and others 2001) projects that the character and location of timber and timber products output will change over the coming half century while timber product prices and forest area will remain stable. The Draft 2000 RPA projects that the area of forestland is expected to decline by 8.4 million ac in the North and to decline slightly elsewhere.

The Draft 2000 RPA Assessment projects that privately owned forests in the United States will be more intensively managed, partly as a response to declining forest area. It also projects that private forests will be expected to produce an increasing share of small-diameter materials for pulp and composite wood products. Timber production overall is projected to continue its shift toward the South, which contains a large share of the nation's private forests. Domestic consumption is projected to increase by two-thirds, while harvests are projected to increase nearly 40 percent over the coming 50 years. Per-capita consumption of roundwood, however, is projected to remain fairly stable, at slightly less than 1 ton per capita per year.

The shares of outputs going into various solid-wood products are projected by RPA to change over the next half-century, much of that driven by evolving technologies that result in rising technical efficiencies. Composite wood structural panels are projected to mostly displace plywood, while softwood lumber shares are projected to grow relative to hardwood lumber. Imports from Canada and elsewhere are projected to rise, especially in the short term. Softwood lumber, pulp, paper, and paperboard production are projected to increase most in the South, especially in the western portion of the region. Although manufacturing efficiency (units of output per unit of wood input) is projected to continue to increase, the rate of that increase is projected to slow, relative to that experienced in the 1900s. Between 2000 and 2050, the output:input ratio is projected to rise by 16 percent.

Hardwood and softwood timber harvests are projected to increase similarly, by over one-third, over the coming half-century. This rise will be made possible by improvements in timber growing technology. A small part of the hardwood production increase is projected to come from short-rotation hardwood plantations ("agrifiber") grown for pulp. This agrifiber is expected to become competitive with forest wood fiber production after 2030. Agrifiber is projected to supply about 5 percent of wood fiber in pulp and panel production by 2050.

The nation's softwood timber harvests are projected to continue to come mostly from the South, rising from 60 percent of U.S. timber harvests today to 67 percent by 2050 (Haynes and others 2001). The shares of softwood provided by the other regions of the country are projected to be steady or to decline over the coming 50 years. In hardwood, production in the Southern and Northern United States is projected to decline in importance while the West rises in importance. Nevertheless, the South and North are both projected to increase their hardwood outputs. By 2050, the South is projected to provide 60 percent of all U.S. fiber production. To a large degree, high productivity of southern softwood plantations is what makes this increase possible.

The RPA Assessment projects that the United States will decrease its dependence on foreign sources of wood fiber (logs, lumber, panels, residues, pulp, waste paper, etc.). The projection shows imports providing 18 percent of wood fiber consumed in 2050, compared to 21 percent in 1996. The relative increase in the use of domestic wood fiber comes at the expense of exports, which are projected to decline from 18 percent of production in 1996 to 11 percent in 2050. These findings are consistent with the shorter run projections of Trømborg and others (2000), which show that the value of United States net exports (exports minus imports) will become more negative by 2010.

An effect of greater investment in manufacturing technology and rising fiber demand is a projected relative rise in the importance of recycled fiber in the paper sector. Use of recycled fiber has been increasing and will continue to do so (Ince 2000). Over the 50-year RPA projection, recycled fiber use is projected to more than double, while wood fiber from timber harvests is projected to increase by one-third.

Timber prices in the United States are projected by RPA to change differentially, depending on product and species. Timber prices for softwood sawtimber and pulpwood are projected to remain steady over the projection. Rising intensity of softwood forest management, especially in southern pine plantations, is expected to permit output to keep up with expanding demand. For hardwood sawtimber and pulpwood, prices are projected to rise significantly, by over two-thirds, by 2050.

5.2.3 Southern Supply, Demand, Management Intensity, and Land Use Projections: SRTS

We used 2000 RPA projections to provide national and global context, but we made projections for the South independently from RPA projections. SRTS projections of forest area, harvests (removals), growth, and inventory were done under all scenarios outlined in Table 1 and described in Section 3 of this Chapter. Starting point data on inventory, net growth, and removals used in the SRTS projections were obtained from the latest Forest Inventory and Analysis data available for download from the FIA website. The years of the latest surveys used are Alabama 1990, Arkansas 1995, Florida 1995, Georgia 1998, Kentucky 1988, Louisiana 1991, Mississippi 1994, North Carolina 1990, Oklahoma 1993, South Carolina 1993, Tennessee 1999, Texas 1992, and Virginia 1992. In States with relatively old surveys, large jumps in plantation areas caused by the large increase in tree planting on private lands since the early 1990s may have been missed (Figure 8). This problem may be most serious in Alabama, North Carolina, Louisiana, Virginia, and Texas. Kentucky, with a last survey date of 1988, has done relatively little planting, historically.

Forest area projections under the IH (Base Case) scenario for FIA Survey Units show the South losing timberland over the coming decades. This loss, amounting to 1 percent over the 1995-2040 projection, is net of an aggregate increase in the area of pine plantations and an aggregate decrease in the area of other forest types (Figure 15). A detailed map of forest area changes (Figure 16) shows that timberland area is projected to increase in the western parts of the South, while losses are projected in States along the southern Atlantic Seaboard. The gains in timberland area, facilitated by rising timber prices relative to agricultural rents, will be concentrated in Alabama, Arkansas, Louisiana, and Mississippi. Significant percentage losses are projected for Florida, North Carolina, South Carolina, Tennessee, Texas, and Virginia. Within States, losses are projected to be concentrated near urban areas, while some rural locations gain forest. This is not universally true, however. For example, all of Florida and South Carolina's FIA Survey Units are projected to lose forest. The South's population and State economies have grown quickly and are projected to continue to grow quickly. With such growth, the demand for land near the urban areas has been, and is projected to continue to be, met by some clearing of forests. Under the IL (Figure 17), EH (Figure 18), and EL (Figure 19) scenarios, aggregate timberland area in the South is projected to change, as well. What all of the figures 15 (IH), 17 (IL), 18 (EH), and 19 (EL) show is that the area of natural forest management types (all types except pine plantations) is projected to shrink, while the planted pine type increases. This trend would appear to be a continuation of that observed over the last 40 years, when little net forest loss was registered but plantation area increased substantially (see HLTH-1, Figure 12).

Common to the IH and IL scenarios, pine plantation areas are projected to increase by 21 to 26 million acres, or by about 67-80 percent from 1995 levels of pine plantations. The pine plantation projections by scenario are displayed together, along with historical amounts, in Figure 20. Increases in pine plantation acres differ among the scenarios considered. These projected increases are similar to the projected acreage of aggregate losses of the natural forest management types, keeping forest area largely unchanged over the projection, 1995 to 2040. Common to the EH and EL scenarios, however, is that pine plantation area is projected to increase by about 25 percent, insufficient to completely outweigh natural forest type losses, translating into a net loss in timberland area of just over 27 million ac (15 percent) between 1995 and 2040. These lower plantation acres are generated because prices, to which pine planting positively responds, do not increase as much under the elastic demand scenarios.

Apparent in the IH (Base Case) and IL scenarios is that pine plantation area is increasing at the "expense" of other forest types, but this trade-off is only partial. As pointed out in HLTH-1, during the 1980s and 1990s, about 30 percent of new pine plantation acres in the South derived from agricultural land, while around 70 percent came from conversion of natural forest management types. Further, part of the loss of natural forest has historically been, and is projected to be, due to conversions to urban uses (see SOCIO-1 for details). Similarly, in the IH and IL projections, a share of the pine plantation acreage increase is projected to be at the expense of agricultural land. In practice, this means that Gulf Coast States and the Coastal and Piedmont regions of Atlantic Coast States will gain the most pine plantations, while northern and interior regions will gain the least plantation area.

A notable actual trade-off, however, exists when comparing the plantation pine and natural forest management type projections done by the IH (Base Case) and IL scenarios. In the IL scenario, softwood prices are projected to rise at a faster rate than they are for the IH scenario; the higher prices in the IL scenario serve as the economic stimulus to landowners to plant even more trees. The difference between the IH and IL pine plantation rates yields the marginal effect of higher plantation growth rates on the area of pine plantations and the area of natural forest types projected for 2040. In the IH scenario, pine plantations are projected to cover 53.6 million ac in 2040, while in the IL scenario the figure is 57.9 million ac. Each percentage point improvement in growth rate above a 50 percent improvement results in about 170,000 fewer acres of projected pine plantations by 2040. Similarly, because the IH scenario projects a natural forest management type area of 122 million ac and the IL projects that area to be 123 million ac, each percentage point improvement in pine plantation growth is projected to "save" about 50,000 ac of natural forest. Alternatively, if timber demand is elastically responsive to timber price, as laid out in the EH and EL scenarios, the effects of pine plantation growth rate changes on areas by management type are very small.

Figure 21 details the changes by State in pine plantation area projected in the IH (Base Case) scenario. Pine plantation area changes vary among Southern States mostly due to differences among States in the area of industry-owned forests, the amount of natural pine forests relative to other types (natural pine stands are converted more frequently to plantations), and land use changes to and from nonforest. The amounts of these plantations projected in the Base Case scenario vary by State and trend upward. All States except Kentucky are projected to gain at least 45 percent in pine plantation area by 2040 compared to 1995, with the largest percentage gains in Tennessee (120 percent), Arkansas (117 percent), and Alabama (89 percent). Georgia, the state with currently the most pine plantations, (6.4 million ac) in 1995, is projected to have the most in 2040 (9.3 million ac). Alabama, with the second most in 1995 (4.0 million ac), is projected to have the second most (7.5 million ac) in 2040.

Under the Base Case scenario, the increases in pine plantations are projected to be largest on an acre basis on the Gulf and Atlantic Coastal Plain and Piedmont ecoregions and smallest in other ecoregions of the South (**Figure 22**). In 1995, the Southeastern Mixed Forest and the Outer Coastal Plain Mixed Forest each contained about 15.4 million ac of pine plantations. They are projected to have 25.6 and 25.4 million ac, respectively, in 2040. The eastern broadleaf forest ecoregions together accounted for about 0.6 million ac of pine plantations in 1995 and are projected to contain a total of 1.2 million ac of such plantations in 2040.

State-level projected changes in timberland area for natural forest management types under the

Base Case scenario are shown in Figure 23. All States are projected to lose acreage in natural forest types under this scenario. States projected to lose most natural forest types between 1995 and 2040 under this scenario are Florida (58 percent), South Carolina (35 percent), and North Carolina (30 percent). These losses can be ascribed to a combination of pine plantation expansion and a loss of forests to residential and urban uses. In other scenarios, the losses projected for natural forest management types in those States are of similar sizes, and those same States are projected to lose most. Arkansas, Louisiana, and Mississippi are projected in other scenarios to either gain no natural forest management type acres or to lose some (up to 14 percent by 2040 for Arkansas, compared to 1995 levels).

An effect of the projected increase in timberland area in planted pine under the Base Case and the IL scenarios is a rise in timber inventories. Under the Base Case scenario, softwood growth is projected to exceed removals during the entire 40-year period (Figure 24). This finding holds for the IL (Figure 25), EH (Figure 26), and EL (Figure 27) scenarios, as well. In the 1990s, in many parts of the South, softwood removals slightly exceeded growth. The projections shown here reflect a turnaround in this situation, although for some States this may take another two decades. The turnaround is attributable to large investments in pine plantations that are growing faster than they are being harvested. Under the Base Case scenario, softwood harvests are projected to increase most in percentage terms in the northern reaches of the South Kentucky, Tennessee, Arkansas, and Oklahoma and least in southeastern parts (Figure 28). In absolute terms (volume per year), the story is more mixed (Figure 28). Large volume increases are projected in some places that have always been major producing regions (Georgia, Alabama, and Louisiana) and in some that have not (parts of the Piedmont and mountains of North Carolina and Virginia, central Tennessee, and the Ozarks of Arkansas). Even parts of the South projected to lose forest area will have rises in softwood harvests. Other places are projected to have decreases in harvests even while forest areas might be stable to rising (parts of Mississippi, Arkansas, and Louisiana). The divergent trends in the Piedmont and in Florida are in some part due to rising productivity of pine plantations and also in part to urbanization. Opposite trends in parts of Louisiana, Arkansas, and Mississippi are mainly attributable to timing: many of the new acres of pine plantations projected in those areas would not be harvested until after 2040.

In aggregate, softwood harvests are projected to increase by 56 percent between 1995 and 2040 under the Base Case scenario. This increase is made possible by the combination of the increase in the area of pine plantations and the projected rise in productivity of those plantations. Nearly half of all southern timber volume growth today occurs in pine plantations, which yield wood at least 50 percent faster than natural pine. Rising productivity over time means that more wood can be produced on a smaller land base.

For hardwoods, the lack of a technology that substantially increases growth means that growth is projected to stay ahead of removals for only two to three decades, after which hardwood inventory is projected to decline. This finding is common to all scenarios and is displayed graphically in Figure 29 (IH), Figure 30 (IL), Figure 31 (EH), and Figure 32 (EL). In the Base Case scenario, growth is projected to exceed removals until about 2025, when removals overtake growth. Much of the high rate of removals increases can be ascribed to a growing demand for hardwood fiber for engineered wood products, especially structural and nonstructural wood panels (Haynes and others 2001).

Hardwood harvests are projected to change unevenly across the South. In percentage terms, projected increases are largest for northern and western parts of the South (Kentucky, Tennessee, northern Alabama, northern Arkansas) and for southern Florida. In the northern portions, these harvests are mostly from areas not projected to lose forests. In Florida, however, much of these harvests are projected to be associated with conversion from forest to urban uses (Figure 33). In volume terms, the story is more complex, reflecting a combination of hardwood volumes entering the market during conversion from forest to nonforest uses, volumes entering the market during conversion of hardwood types to pine plantations, and higher harvesting rates in hardwood forests that are projected to remain hardwood forests (Figure 33).

Across all States and species combined, projected trends for growth and removals differ by ownership in the IH (Figure 34), IL (Figure 35), EH (Figure 36), and EL (Figure 37) scenarios. In both the IH and the IL scenarios, until about 2030, growth is projected to exceed removals on nonindustrial forestland. On industry land, growth is projected to exceed removals throughout the projection period. Under both elastic (EH, EL) scenarios, growth is projected to exceed removals for both NIPF and industry ownership groups in aggregate throughout the projection. The different trends on NIPF and industry land in the inelastic scenarios occur because forest industry landowners are projected to invest heavily enough in plantations that their higher growth would keep up with the relatively inelastic and increasing demand. NIPF owners, however, have more land in natural forest management types, which are projected to decline in area over time, and their pine plantations are not projected to improve in productivity as much as industry plantations.

Changes in management type acreages toward more pine plantations and fewer acres in natural forest management types will affect age structure of southern forests. Softwood forests are projected to become younger (Figure 38 shows this for the base case). Part of the increase in the younger age classes is caused by pine plantations being harvested by around age 30 years, while the natural pine (natural pine and the pine in mixed oak-pine) is harvested at a higher age. The amount of such natural pine is projected to decline. Hardwood forests are projected to become somewhat bifurcated in age structure, with a growing share of volume residing in older age classes and a shrinking share in the middle age classes (10-40 years) (Figure 39). The shrinking middle age classes in hardwood result mostly from relatively lower harvesting pressure (relative to pine) in this type. Much of the middle-aged volume therefore enters the oldest age classes over time.

Southwide changes in inventory resulting from forest land area changes, management type area changes, and plantation growth mask variations on those changes on smaller spatial units. For most States, inventories of both hardwood and softwood are projected to always exceed those present in 1995. This finding can be obtained by examining the differences between growth and removals for both hardwood and softwood. Figure 40 shows the growth and removals projections for Alabama, while analogous figures are offered for Arkansas (Figure 41), Florida (Figure 42), Georgia (Figure 43), Kentucky (Figure 44), Louisiana (Figure 45), Mississippi (Figure 46), North Carolina (Figure 47), Oklahoma (Figure 48), South Carolina (Figure 49), Tennessee (Figure 50), Texas (Figure 51), and Virginia (Figure 52). Across most States, growth and removals of both hardwood and softwood species are projected to increase through 2040. Some exceptions are in Mississippi and South Carolina, where hardwood removals outpace growth during the entire projection. The falling hardwood inventories can be ascribed primarily to vigorous conversion of natural forest management types to pine plantations. Softwood inventories in both States are projected to rise through 2040. Kentucky and Oklahoma, with large inventories relative to local demand, are projected to have steadily rising inventories of both hardwood and softwood throughout the projection.

Timber prices are useful indicators of timber scarcity or abundance. Prices are projected to go up in real (adjusted for inflation) terms between 1995 and 2040 under all scenarios and for both softwood (Figure 53) and hardwood species (Figure 54). Under both of the inelastic (IH, IL) timber demand scenarios, softwood timber prices are projected to increase by at least two-thirds between 1995 and 2040. Under the elastic scenarios (EH, EL), these prices are projected to increase by 8-10 percent. For hardwood, a similar story emerges: under IH and IL, prices are projected to rise by about 82 percent, while under the EH and EL scenarios, the increase is 10 percent. Thus, real price increases will serve as incentives for continued investment in intensive timber growing technologies. Rising prices therefore help to counteract the trend toward land conversion away from forest, while such price trends also encourage forest type conversions to plantations and, to a lesser extent, agricultural land reversions to forest.

The effects of rising timber prices may be felt in the timber product sector by inducing substitutions and technology changes. The SRTS model used in this Assessment does not have a mechanism for directly incorporating such dynamics. It is clear, however, that higher timber prices translate to higher incomes for timber producers. Timber price increases, on the other hand, mean that final product prices also will rise (though not necessarily in proportion) in a manner similar to that projected under the timber demand and supply scenarios outlined here. Consumers of these products will be encouraged, through price rises, to substitute nonwood products for wood products in the construction industry. Paper product manufacturers may also have a rising incentive to seek greater imports of pulp fiber, use more recycled fiber furnish, and further increase the efficiency of fiber use. It is also possible that the mix of timber products will shift over time, as timber is harvested at a younger age. Because smaller trees are generally less suitable for solid wood products, rising wood prices will continue the trend toward greater use of engineered wood products.

6 Discussion and Conclusions

The Southern United States is the largest single producer of timber products in the world. Most of the region's production comes from private land and is consumed domestically, and projections suggest that these facts will remain unchanged. The South has become increasingly prominent in domestic timber product markets because of rapidly increasing productivity on private land, improved product manufacturing technology, and the shrinking timber harvests in other parts of the country. Projections of the Draft 2000 RPA show that the South will remain the nation's dominant timber producing region, and those of SRTS given here appear to support that finding. Continued dominance over the next several decades will be enabled by steadily advancing technology in timber growing and wood utilization and limited harvest increases in other parts of the United States. The South's dominant role will depend partly on an increasing rate of harvest of hardwood resources. Hardwood volume growth will outpace harvest volume for at least 25 to 30 years. Southern industrial and nonindustrial timberland owners are expected to continue to invest in and expand the area of pine plantations. Faster growth and higher harvest frequency of such plantations enable substantial increases in aggregate output of softwood. Despite the rising role of the South and the rapid rise in production from pine plantations, output is not projected to keep pace with demand expansion, and higher prices are projected to be the result. The rising prices will likely mean rising product imports and continued changes in product manufacturing technologies, which will combine to partially offset the effects of more expensive timber on the prices of wood-based final products.

One result of the projected increasing prevalence of pine plantations is a continued decrease in the area of natural forest types. Part of the loss of natural forest types, however, comes from the liquidation of forests to accommodate urban expansion. Such land-use pressures are projected to depress the total area of forest in some parts of the South, especially in the heavily populated Atlantic Coast States from Virginia to Florida. The loss of forest there is projected under the base case scenario to be offset in the aggregate by the gains in some parts of the northern and western regions of the South.

The projected increase in acreage and growth rate of southern pine plantations imply that forest product manufacturing opportunities will rise. Investment opportunities will exist for developing capacity and technology to utilize small diameter logs, coming from pine plantations. But such rising economic opportunities may have to be squared with, or be limited by, issues surrounding the losses of some ecological values associated with the losses of natural management types.

It is important to note that the forests of South are not projected to be dominated by pine plantations. Although the projected rise in pine plantation area is to match the projected fall in natural forest area in our base case scenario, natural forest types in all scenarios are projected to be the dominant forest cover in the region. In some places, such as southern Georgia and northern Florida, however, pine plantations are projected to dominate the landscape. Along the Atlantic and Gulf Coastal Plains from North Carolina to Texas, pine plantations are projected to be the largest single forest management type, but they will not comprise a majority of forests on most of the Coastal Plain. Nevertheless, a question remains as to whether the large plantation acreage increases projected for some regions under some scenarios would be acceptable to local residents, for whatever reasons, or whether any local opposition to them would stop them from being established.

The projections reported here are based on validated empirical models of land use, timber supply and demand relationships, and reasonable assumptions about timber demand growth. The projections rely on what have been shown to be relatively stable patterns of product consumption, economic growth, technological change, population growth, and land use choices. As with all such models, projections are contingent on the stability of economic relationships, consumer tastes, and assumptions about changes in national and world economies. Further, the emergence and success of not yet conceived technologies is impossible to gauge.

The forest sector depends heavily on long production periods and large capital investments, and these characteristics would seem to work in favor of making valid projections of the future. People can be reasonably expected to continue to demand wood for furniture and housing and paper for packaging and writing. Hence, projections about the sector over coming decades can be made with some confidence by evaluating the growth of trees already in the ground and timber product manufacturing capacity already in place. As a result, forest sector projections may be more reliable than similar projections made for other sectors of the economy. Nevertheless, the details of projections are notoriously unreliable. Hence, one should not view the projected dates of key thresholds, peaks and troughs with confidence. Instead, one should view the projections as maps of overall trends if current consumer preferences, supply and demand relationships, and trends in technology remain stable. Expect the future of projected variables to mimic the bumpiness of the past, when there were periods of increases and periods of decreases in forest area, harvests, prices, product shares, and trade.

7 Needs for Additional Research

Most of the issues identified by the public and by forest sector analysts were addressed in some way in this Chapter. Some issues could not be addressed due to data limitations and a lack of a complete understanding of certain structural relationships. First, many of the linkages between competing products could not be evaluated because of a lack of solid empirical estimates of those linkages. Expanded understanding of those relationships through empirical modeling would improve the accuracy of SRTS as well as RPA projections of the kinds reported here. Further, in SRTS modeling, projections could not be made with confidence at scales smaller than the Survey Unit of where pine plantations would be established and hence which natural forest management types would be lost there as a result. Improved understanding of how decisions are made for locating plantations would improve the level of detail offered by SRTS.

The South is undergoing rapid urbanization, and the land use projections arising from SRTS modeling suggest that this trend will continue. Demographics of landowners will change as the population ages and becomes wealthier. Urbanization and demographic changes are likely to result in increased fragmentation of both forests and their ownership, but we do not know how much new fragmentation will occur or how it may affect the values and commodities obtained from forests. Better estimates of land use and forest type trends at fine spatial scales could result from a better understanding of fragmentation and urbanization.

Highlighted in this Chapter are large historical and projected future increases in pine plantation area and decreases in natural forest management types. The pine plantation area projections can be made at the level of the FIA Survey Unit, but this level of model resolution is not adequate for projecting the effects of economic and demographic trends on pine plantations at the kinds of finer spatial resolution that would be useful for making many kinds of ecological and economic projections. A new generation of land use models that can predict with accuracy the proportion of forest in pine plantations on small spatial units, such as at the scale of counties or finer, would therefore make such projections more useful. To develop such empirical models, however, reliable data are needed on land uses in those finer spatial units.

A key issue for further research is better understanding of how sustainability policies affect timber supply, demand, and the ecological characteristics of forests. Sustainability of forest uses in the South might be assured through more stringent government regulation of private landowners. Alternatively, sustainability could result from changes in consumer preferences. In either case, the expense of managing and harvesting timber would change, affecting timber supply and demand. More complete understanding of the effects of sustainability policies could facilitate decision making in both private and public sector planning and policy development.

An emerging issue that may merit investigation for its potential impacts on timber supply and demand is the promulgation of laws or the appearance of market incentives to sequester carbon in forests. Sequestration, done to reduce atmospheric carbon and mitigate apparent climate change, could be encouraged through subsidies, tax incentives, regulations, or voluntary creation of a national or world carbon-credit trading system. In any case, sequestration would probably involve longer rotation lengths (forest growing periods) and larger diameter trees, and so there would be ecological and timber product market consequences. Timber product markets reliant on large-diameter materials (e.g., sawtimber) might grow relative to markets utilizing primarily small diameter materials (e.g., pulpwood), but quantifying the full effects of alternative policies and market mechanisms would be useful to policy makers, climate modelers, and the timber product sector.

Finally, little is known about the potential effects on timber markets of introducing short-rotation woody crops into the fiber supply. These crops, often of hardwood tree species, would produce a kind of fiber useful for certain products (especially printing and writing papers and nonstructural panels) and not others. New sources of fiber could dampen the hardwood pulpwood price increases that have been projected for the future in this Assessment and could affect land use and timber production patterns. Little is known about where these woody crops would be grown, the scale of their production, or their ecological implications. But the prospect of their emergence merits new investigation.

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10 Tables and Figures

Table 1--Subregional Timber Supply Model (SRTS) assumptions

Variable	Scenarios[a]	Species	Ownership	Value	Source of the Assumption
Assumed annual outward shift (increase) in timber demand	All	All	All	1.6%/yr	1993 RPA
Southern pine plantation area elasticity with respect to timber price	All	All	Industry	0.60	Murray and Lee (1990)
	All	All	NIPF	1.8	Murray and Lee (1990)
Timberland area elasticity with respect to timber price	All	All	All	~0.3	Hardie and others (2000)
Rural area elasticity with respect to Population, Income, and Agricultural Rents	All	All	All	Imbedded	Hardie and others (2000)
Supply price elasticity	All	Hardwood	All	0.45	Adams and Haynes (1996)
	All	Softwood	All	0.29	Adams and Haynes (1996)
Demand price elasticity	IH	All	All	0.50	Abt and others (2000)
	IL	All	All	0.50	Abt and others (2000)
	EH	All	All	5.00	This Assessment
	EL	All	All	5.00	This Assessment
Southern pine plantation growth rates	IH	All	Industry	75% by 2040	This Assessment

growth rates	IH	All	NIPF	37.5% by 2040	This Assessment
	IL	All	Industry	50% by 2040	This Assessment
	IL	All	NIPF	25% by 2040	This Assessment
	EH	All	Industry	75% by 2040	This Assessment
	EH	All	NIPF	37.5% by 2040	This Assessment
	EL	All	Industry	50% by 2040	This Assessment
	EL	All	NIPF	25% by 2040	This Assessment

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Table 2--Direction of trade among major timber products trading countries, 1997, US$ million

Exporter	Importer								
	Brazil	Canada	Europe	Indo-nesia	Japan	Malaysia	Russian Fed.	USA	ROW[a]
Brazil		44	1,027	69	208	5	0	724	797
Canada	187		2,551	122	3,201	57	3	18,053	906
Europe	309	225		214	252	165	385	2,170	58,380
Indonesia	3	31	636		2,059	90	1	471	1,803
Japan	11	19	87	55		92	1	258	1,117
Malaysia	0	9	421	24	1,826		0	143	1,603
Russian Federation	2	4	1,536	4	787	5		70	492
USA	388	3,073	4,050	233	3,752	142	14		4,046
ROW[a]	199	59	2,326	256	3,106	247	56	1,334	

[a]Rest of the world. Source: United Nations Food and Agricultural Organization (2000)

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Figure 1--Schematic of the Subregional Timber Supply (SRTS) model. (Source: Abt and others 2000).

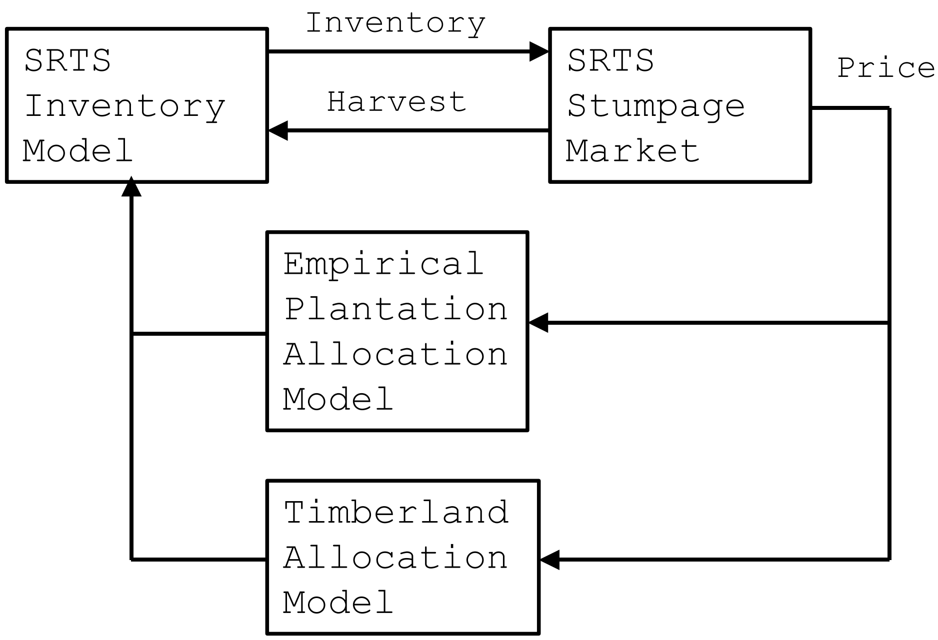

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Figure 2--Total United States harvests, national forest harvests, and United States real gross domestic product, 1950-1998. Data Sources: Cut volume on National Forests: National Forest System, United States Forest Service, October, 2000; Harvest Volumes, Total: Ken Skog, Forest Products Laboratory, USDA-Forest Service, October, 2000; GDP: United States Department of Commerce (November 16, 2000).

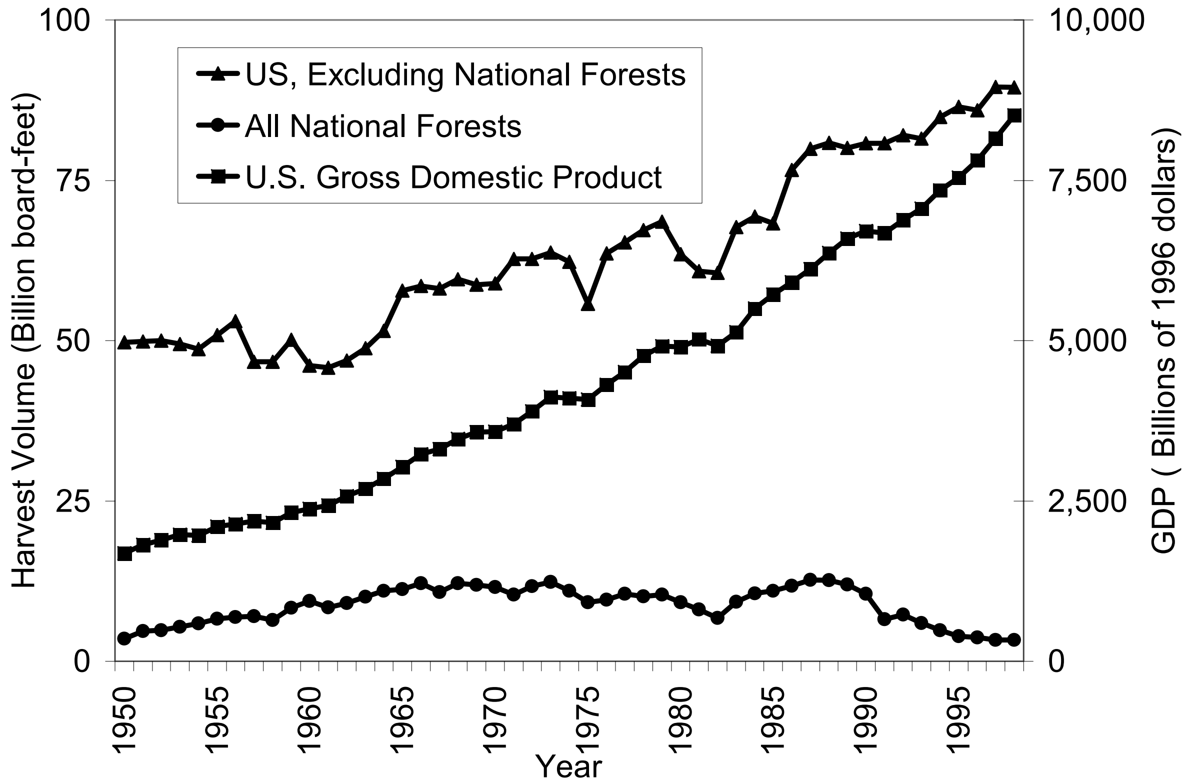

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Figure 3--National Forest harvests by geographical region. Note: PNW is the Pacific Northwest (Region 6) National Forests, "Other West" is the sum of Rocky Mountain (Region 2), Southwestern (Region 3), Intermountain (Region 4), Pacific Southwest (Region 5), and Alaska (Region 10). "Other East" is the sum of Northern (Region 1), Eastern (Region 9), Tropical (Puerto Rico), and the former Region 7. Data Source: National Forest System, USDA-Forest Service, October, 2000.

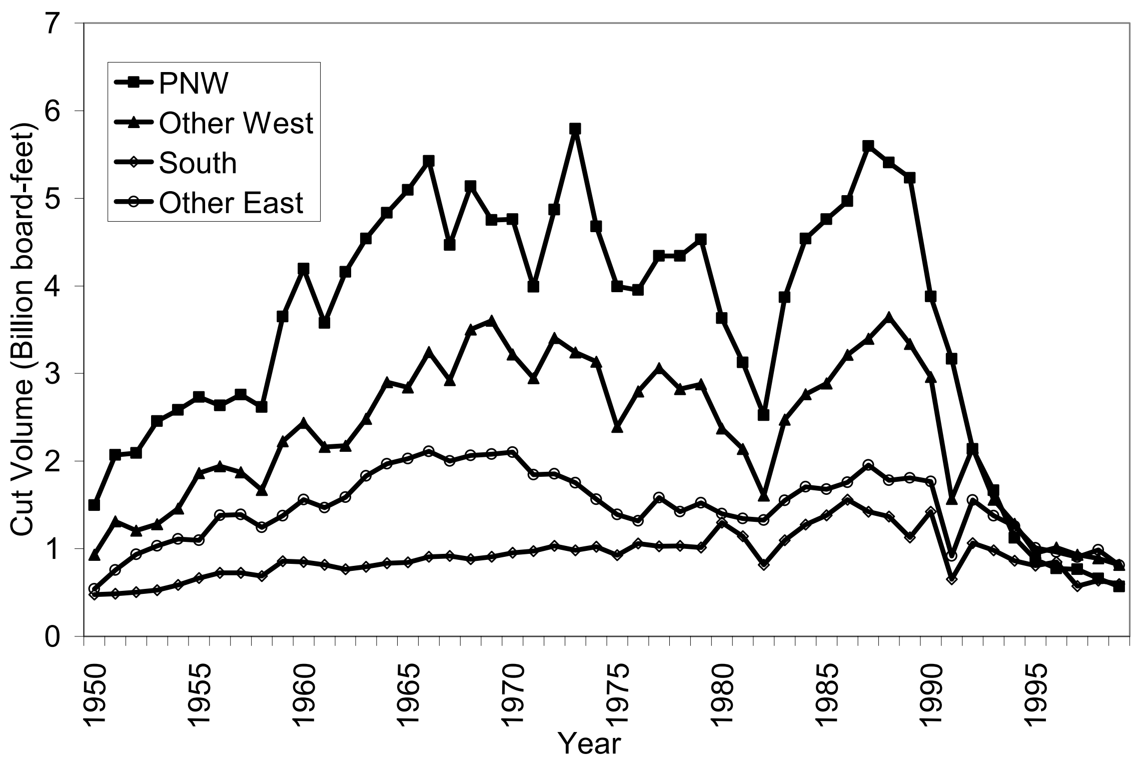

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Figure 4--United States fiber consumption, by source, 1965-1998. Data Source: Peter Ince and Kenneth Skog, Forest Products Laboratory, USDA-Forest Service, October 2000.

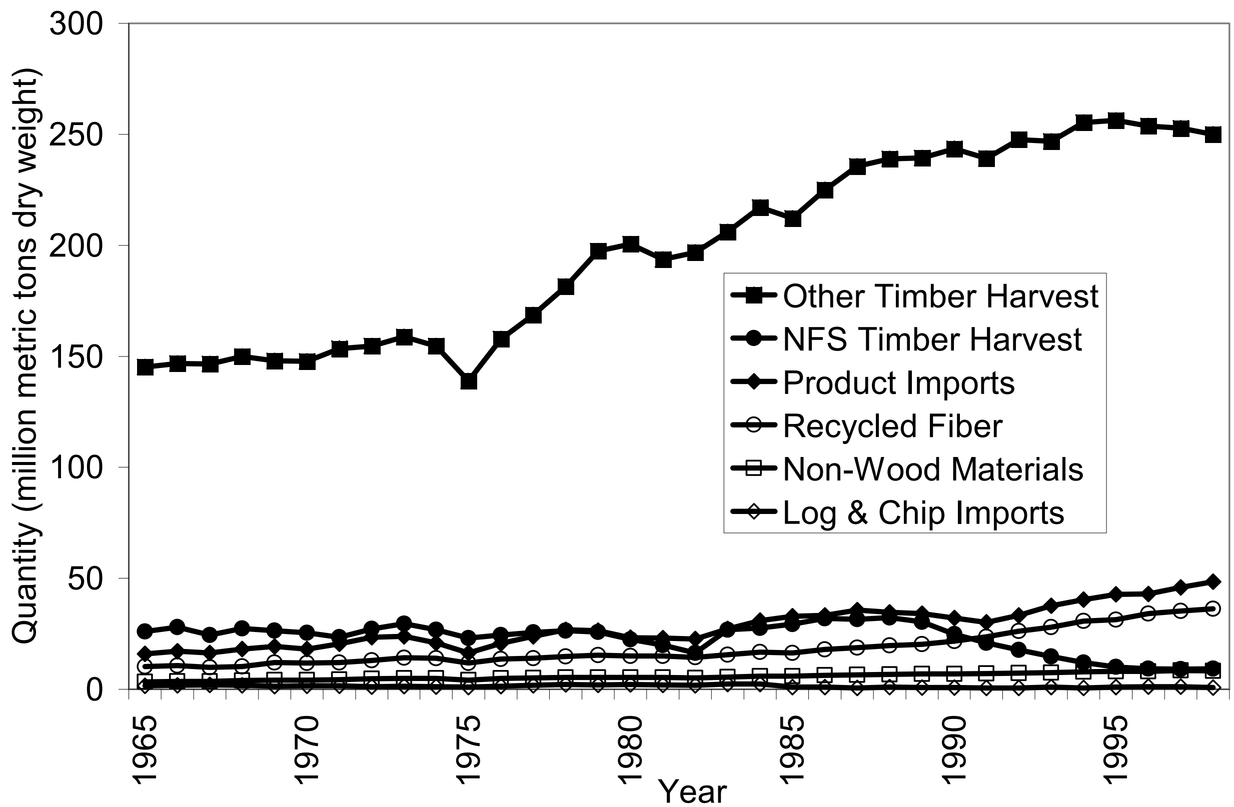

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Figure 5--Industrial wood productivity in the United States, 1900-1998. Source: Peter Ince, Forest Products Laboratory, USDA-Forest Service, October 2000.

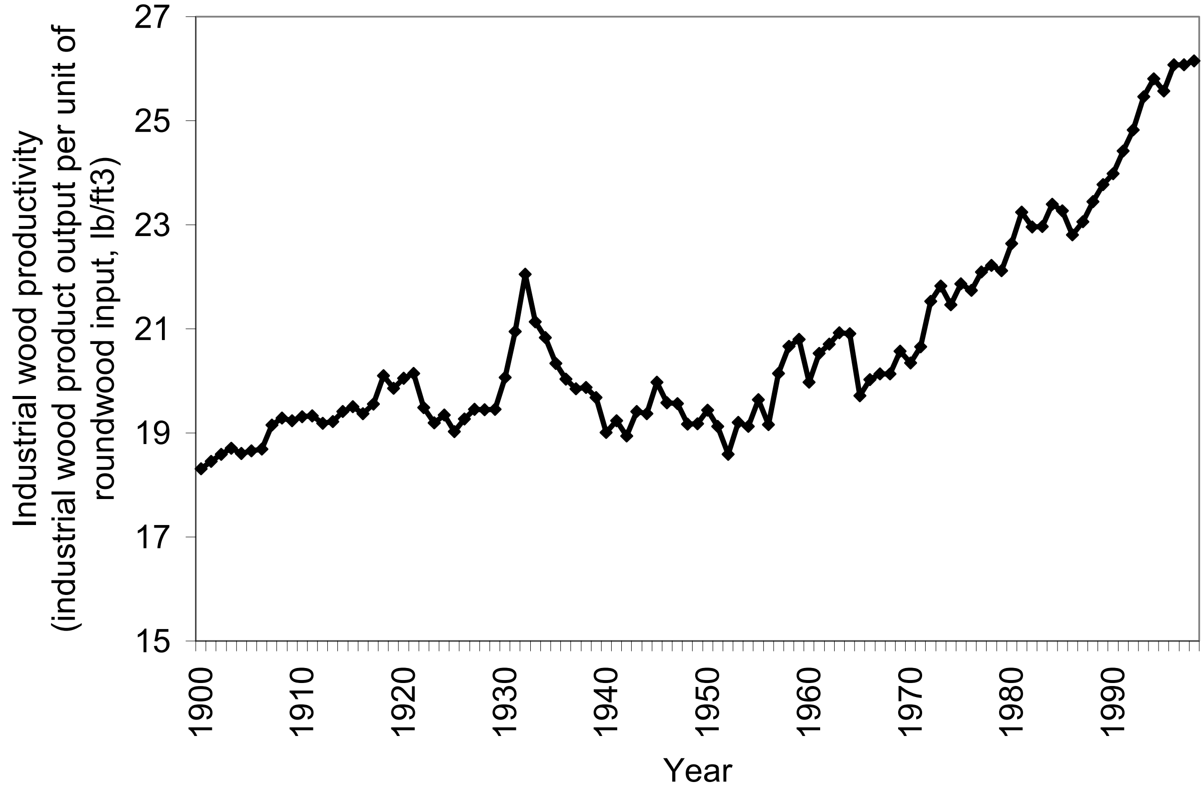

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Figure 6--Shares of timber harvest volumes, by Region of the United States, 1952-1997. Source: Haynes and others (2001).

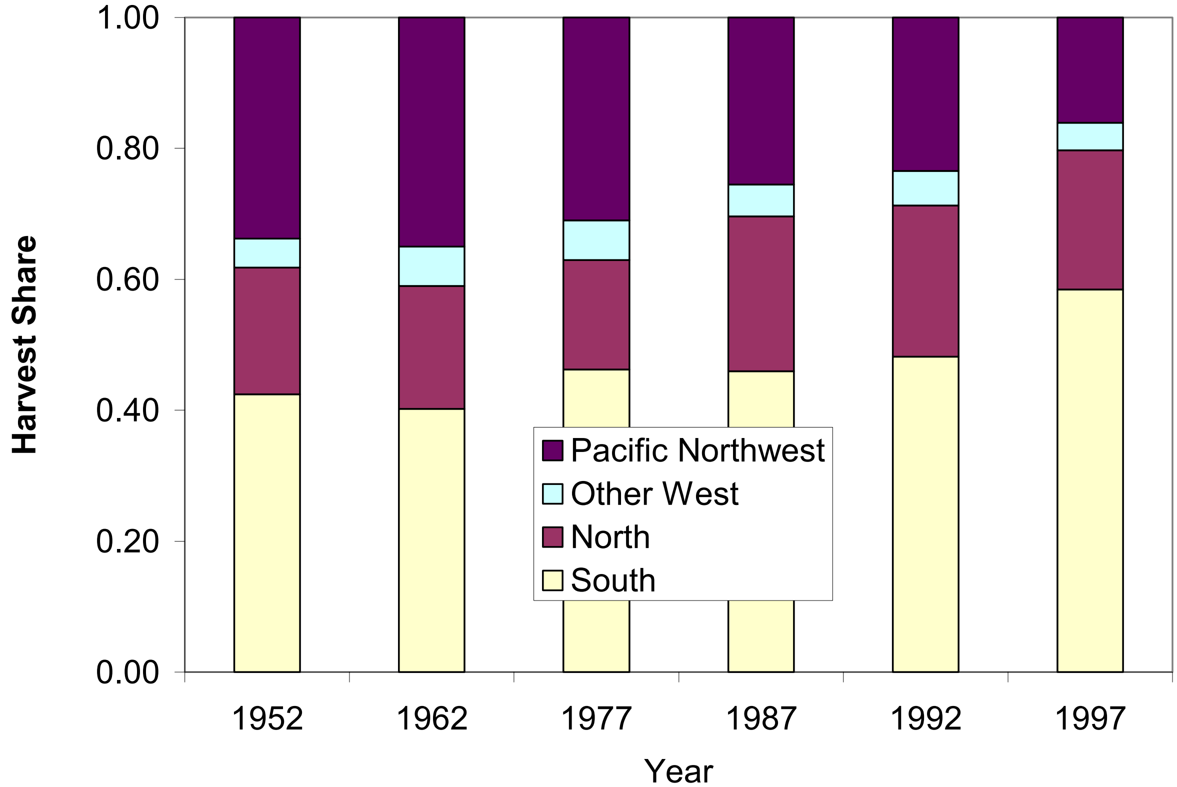

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Figure 7--Timber harvest revenues, by Region of the United States, 1952-1997. Sources: and David N. Wear, Southern Research Station, USDA Forest Service (2000).

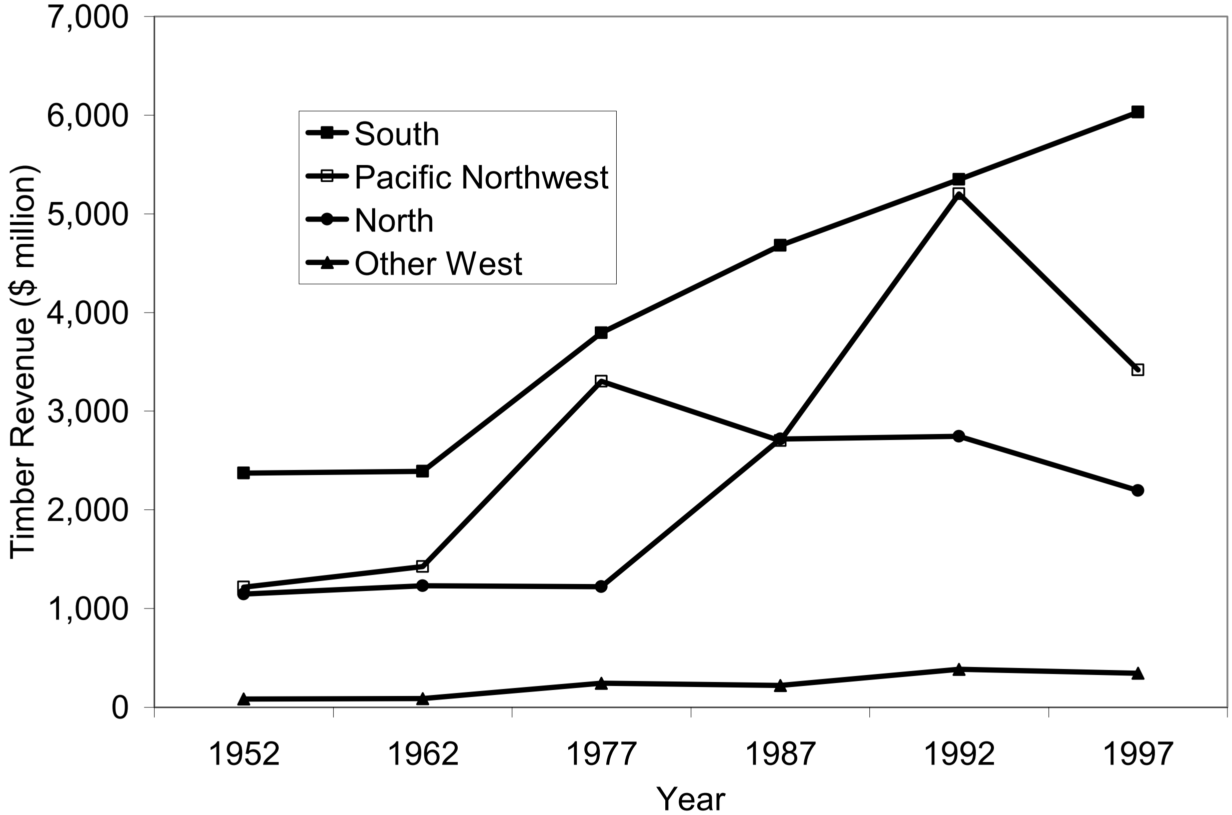

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Figure 8--Tree planting in the South, by major owner group, 1945-1999. Source: Robert F. Moulton, compiled from annual USDA Forest Service tree planting reports; and including estimates for industry (Arkansas 1954, Florida 1981; Georgia 1954 and 1982; Louisiana 1954 and 1981; Mississippi 1954; and Texas 1981).

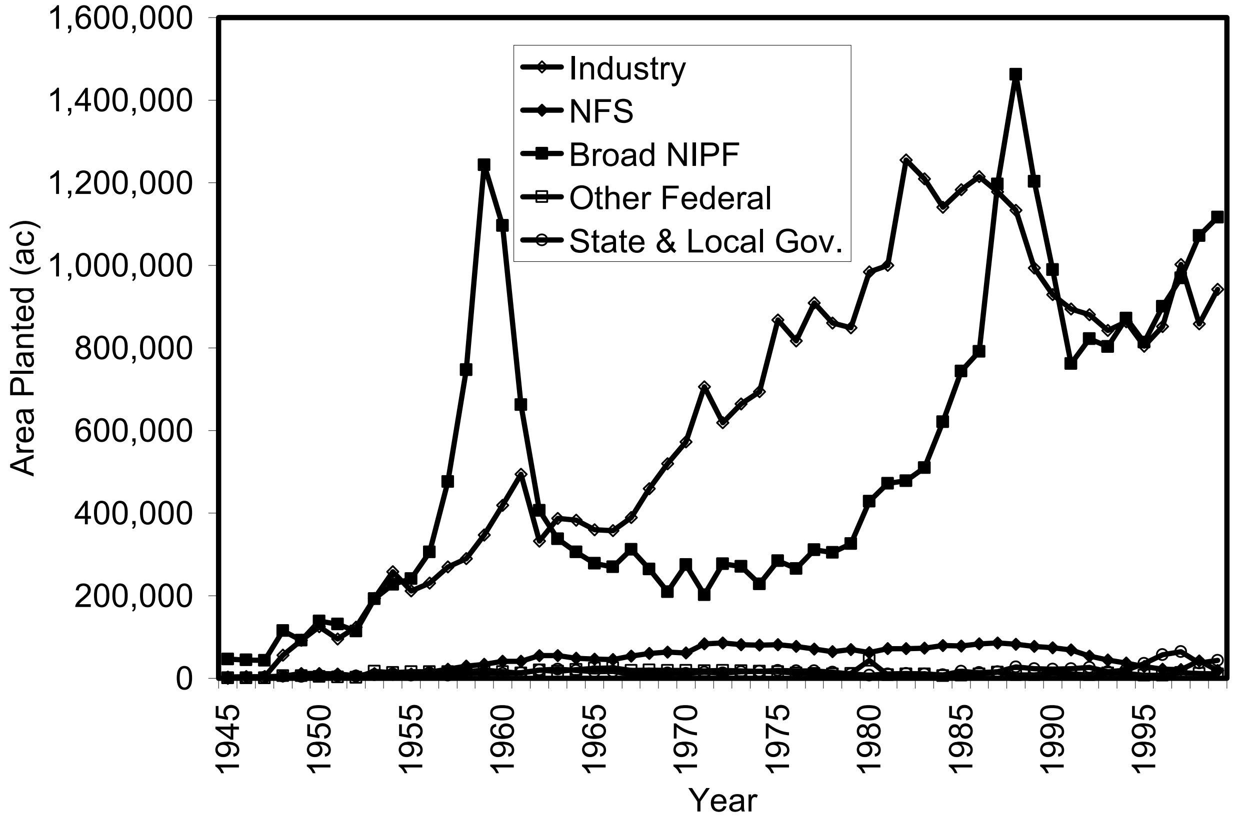

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Figure 9--Southern pulpwood production, 1953-1998, by product class, and Louisiana southern pine and hardwood pulpwood stumpage prices, 1955-1998. Sources: Johnson (1996), Johnson and Howell (1996), Johnson and Steppleton (1996, 1997, 1999), and Louisiana Department of Agriculture and Forestry (2000).

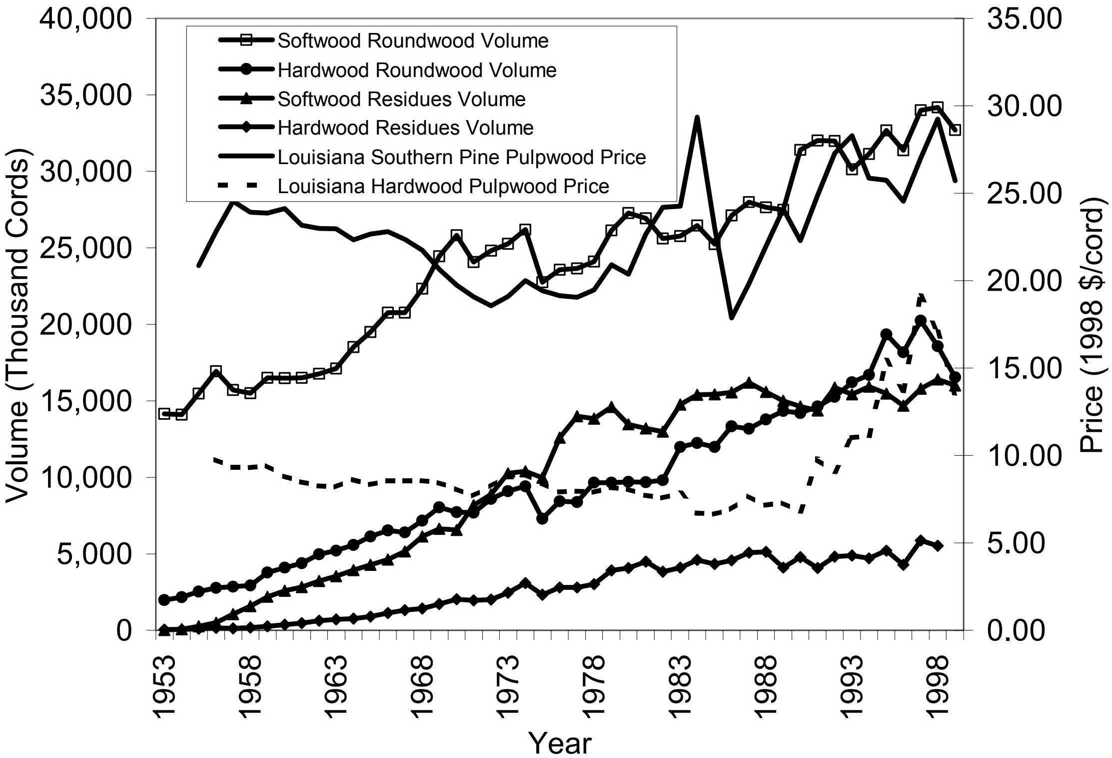

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Figure 10--Chip mills in the United States South. Source: Hyldahl and others (2000).

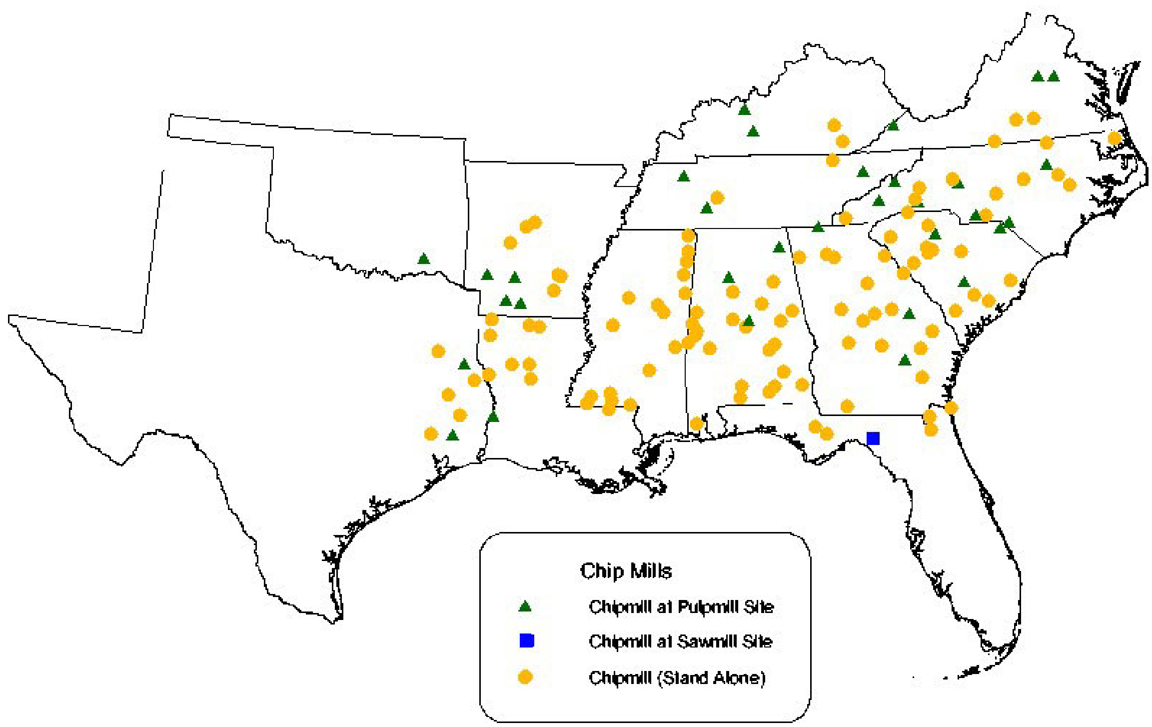

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Figure 11--Other wood-using mills in the United States South. Source: Prestemon and Pye (1999).

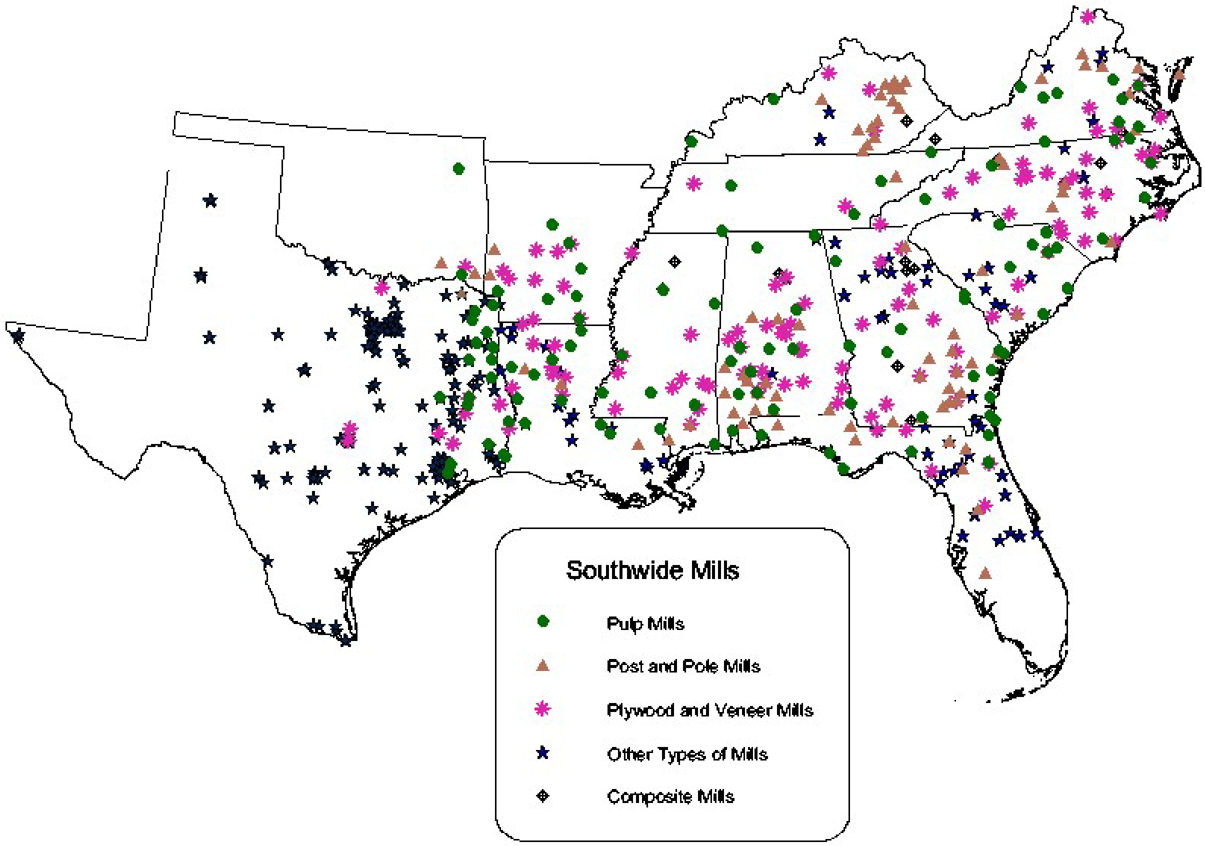

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Figure 12--Sawmills in the United States South. Source: Prestemon and Pye (1999).

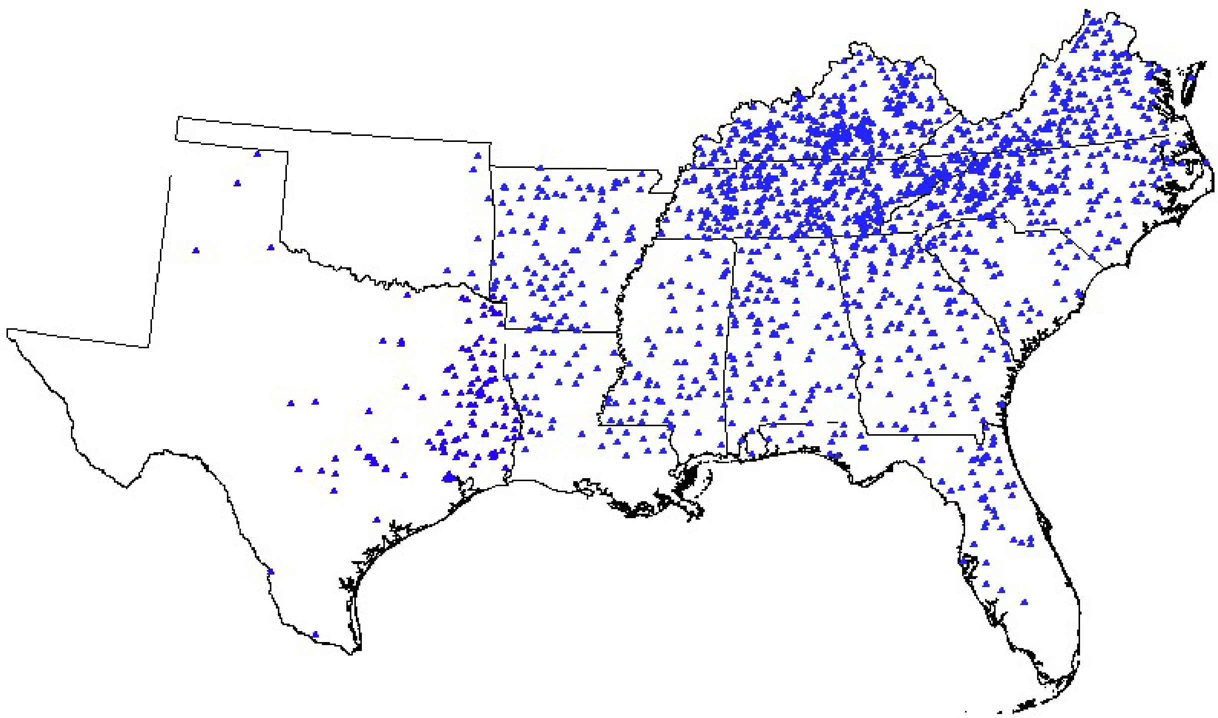

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Figure 13--Southern wood residue production (1953-1999) and wood chip exports from southern customs districts (1989-1999), softwood and hardwood.

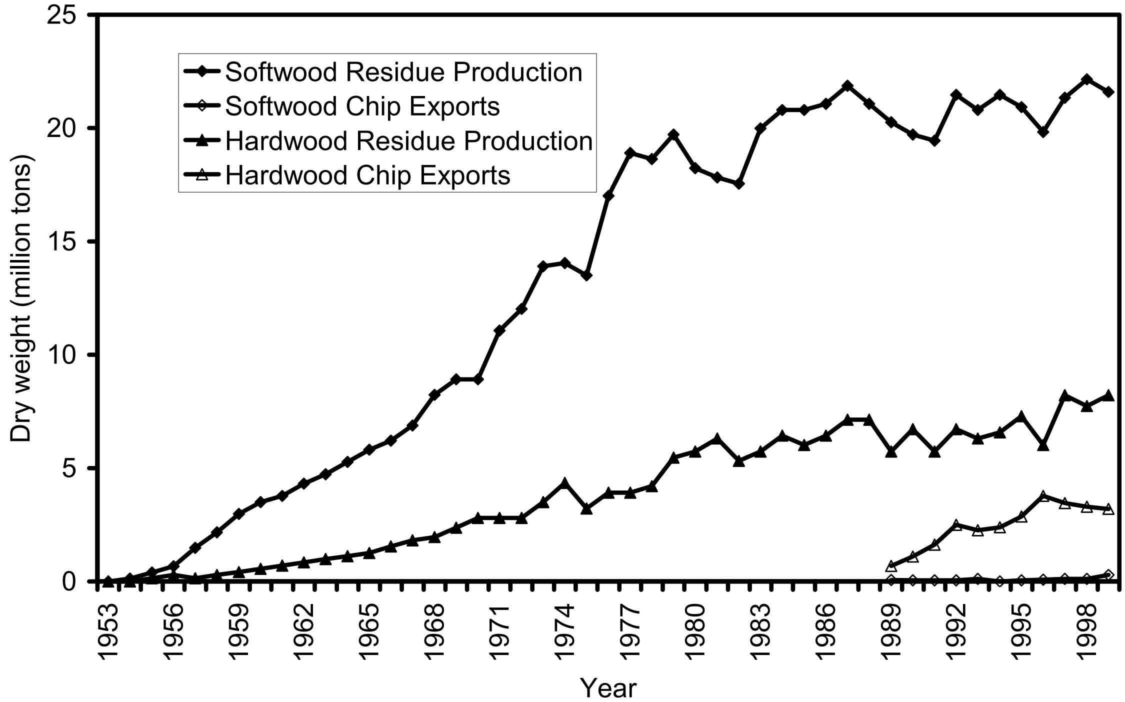

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Figure 14--Removals by destination product, southwide, all species, 1952-1996. Sources: USDA-Forest Service (1958, p. 570, 641-642; 1982, p. 422), Hair (1963, p. 32-33), Phelps (1980, p. 31), Waddell and others (1989, p. 89), Powell and others (1994, p. 36), and Haynes and others (2001). Note: Data for 1954-1972 on "All Other Products" include fuelwood.

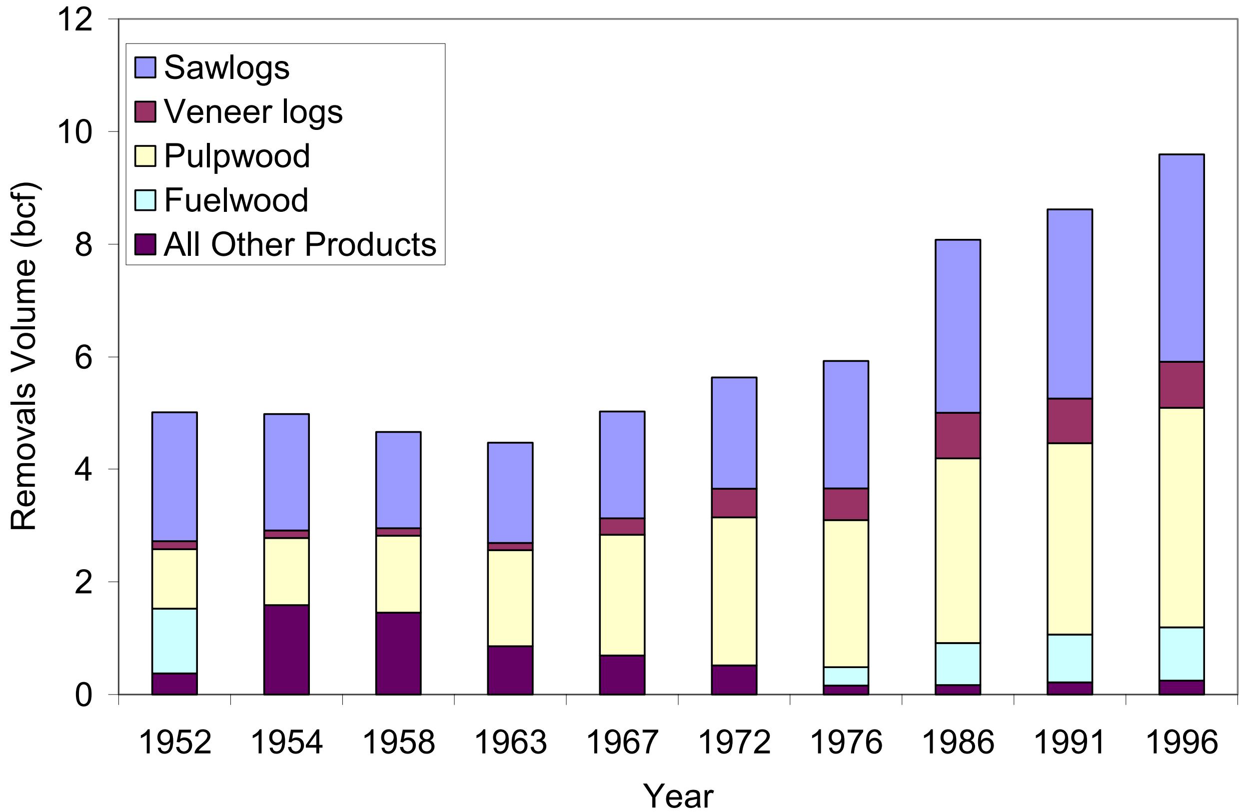

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Figure 15--Subregional Timber Supply Model projections of timberland area by management type, 1995-2040, under the IH (Base Case) assumptions of inelastic timber demand and high plantation volume growth rates.

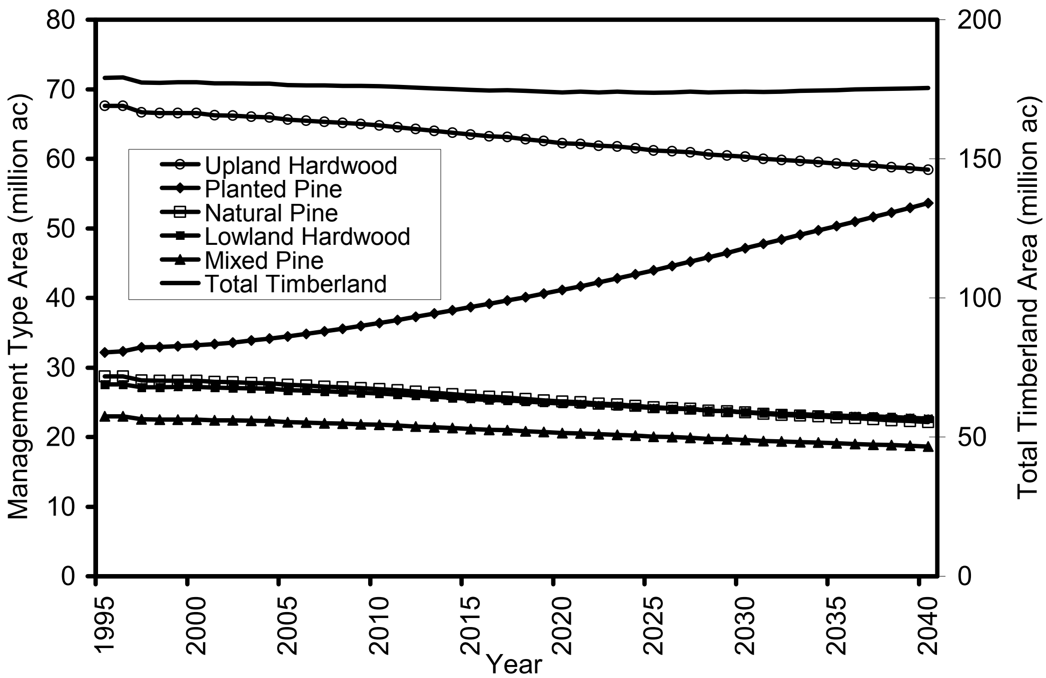

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Figure 16--Subregional Timber Supply Model projections by FIA Survey Unit of percent change in timberland area, 1995-2040, under assumptions of inelastic timber demand and high plantation volume growth rates.

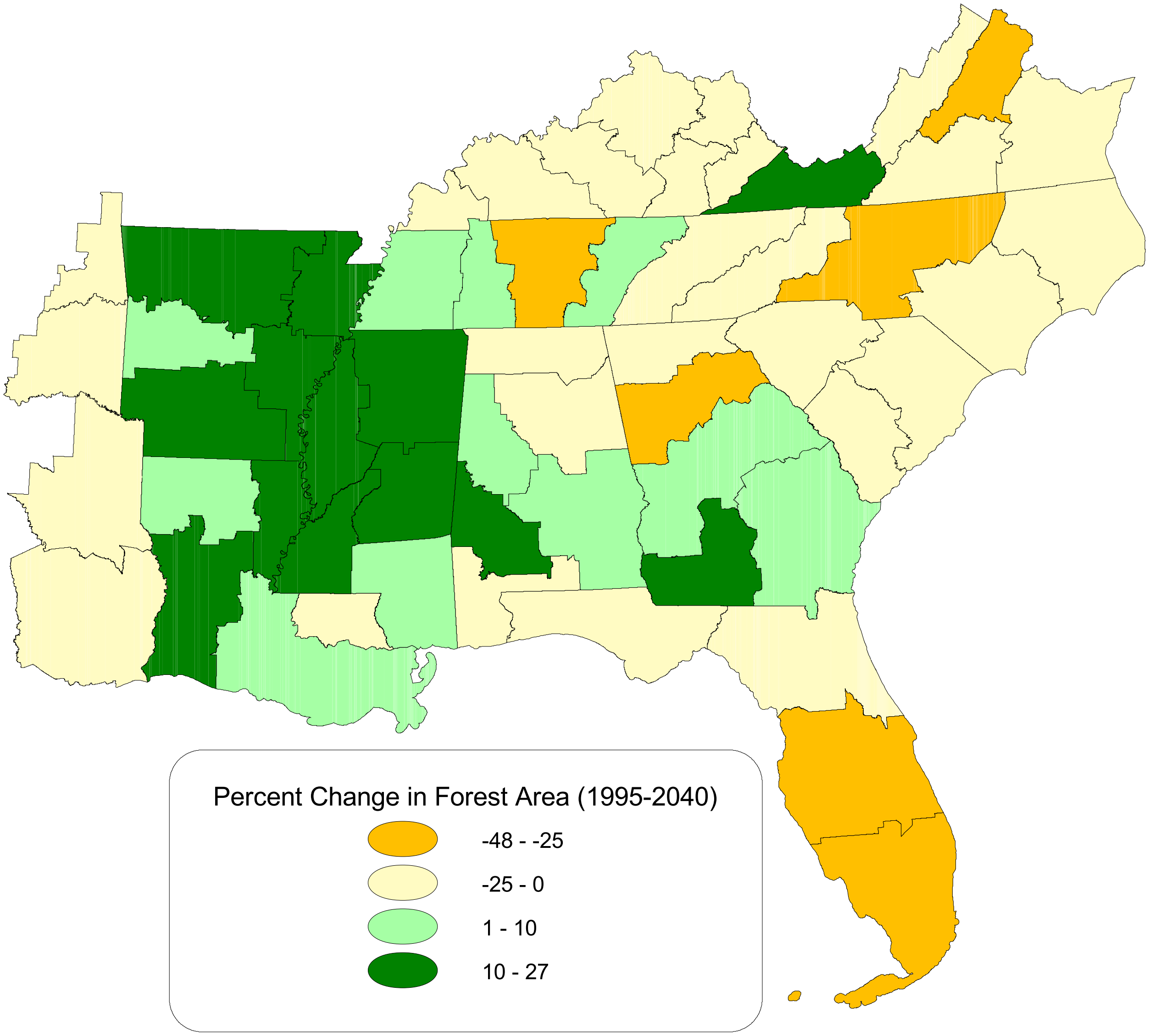

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Figure 17--Subregional Timber Supply Model projections of timberland area by management type, 1995-2040, under the IL assumptions of inelastic timber demand and low plantation volume growth rates.

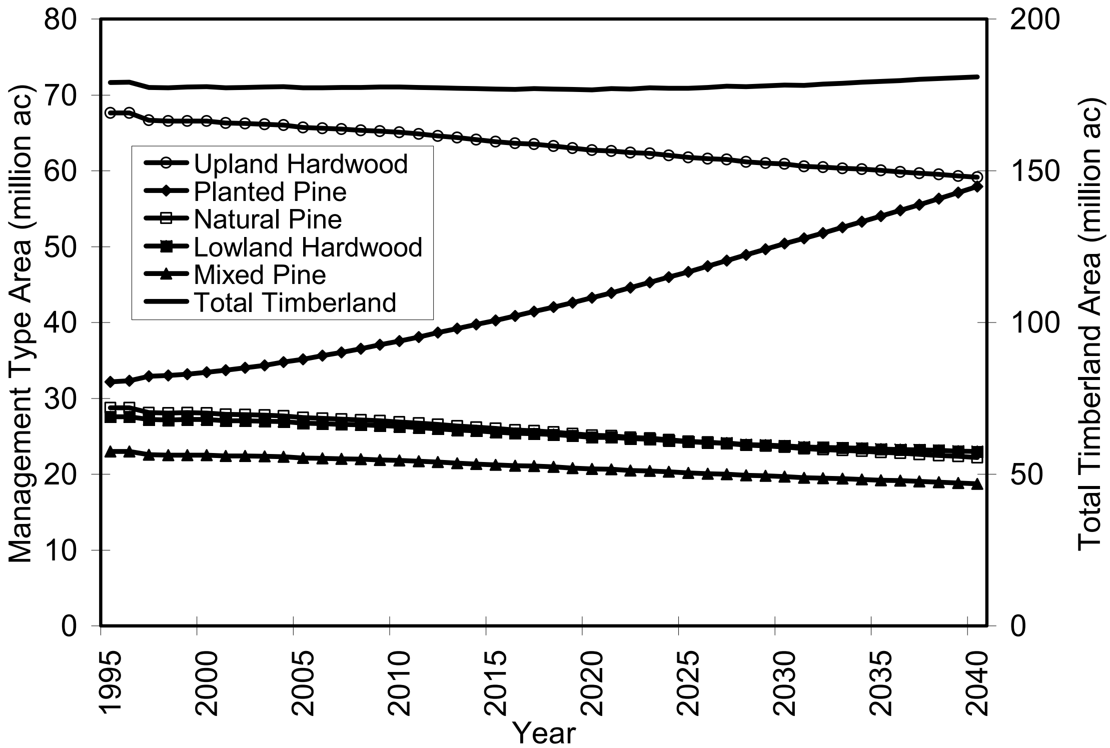

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Figure 18--Subregional Timber Supply Model projections of timberland area by management type, 1995-2040, under the EH assumptions of elastic timber demand and high plantation volume growth rates.

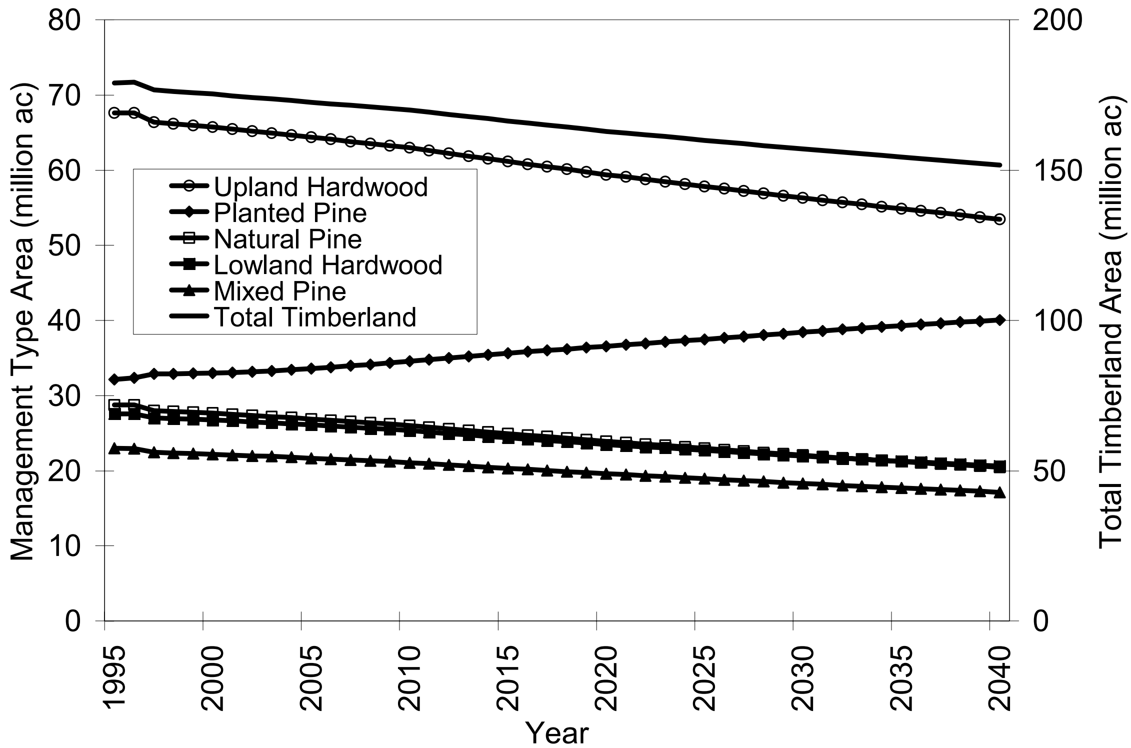

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Figure 19--Subregional Timber Supply Model projections of timberland area by management type, 1995-2040, under the EL assumptions of elastic timber demand and low plantation volume growth rates.

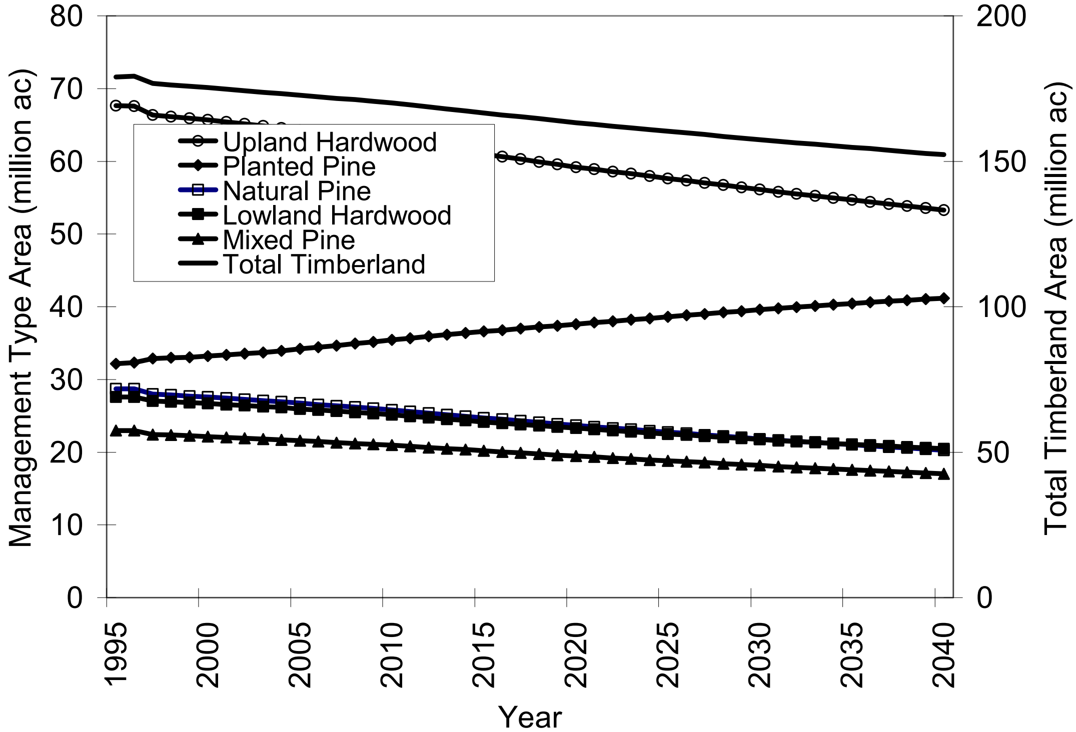

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Figure 20--Pine plantation area projections by scenario, and historical pine plantation area (million ac), 1952-2040.

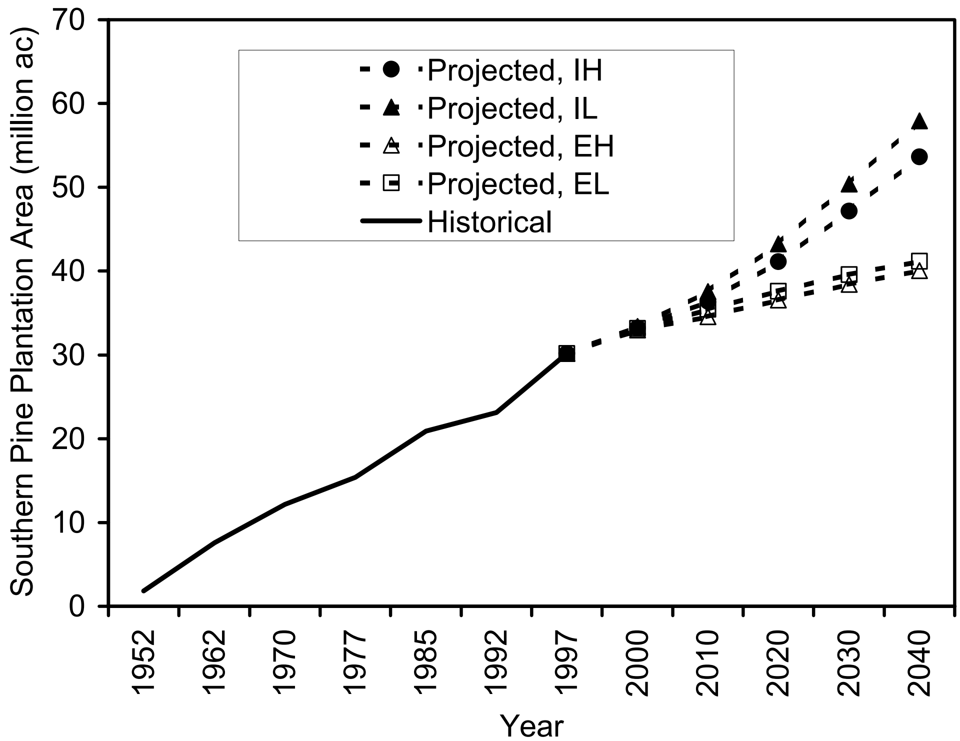

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Figure 21--Pine plantation area by state in the South for 1995, 2020, and 2040, as projected by SRTS, under the IH (Base Case) scenario, with inelastic demand and a high pine plantation growth rate increase.

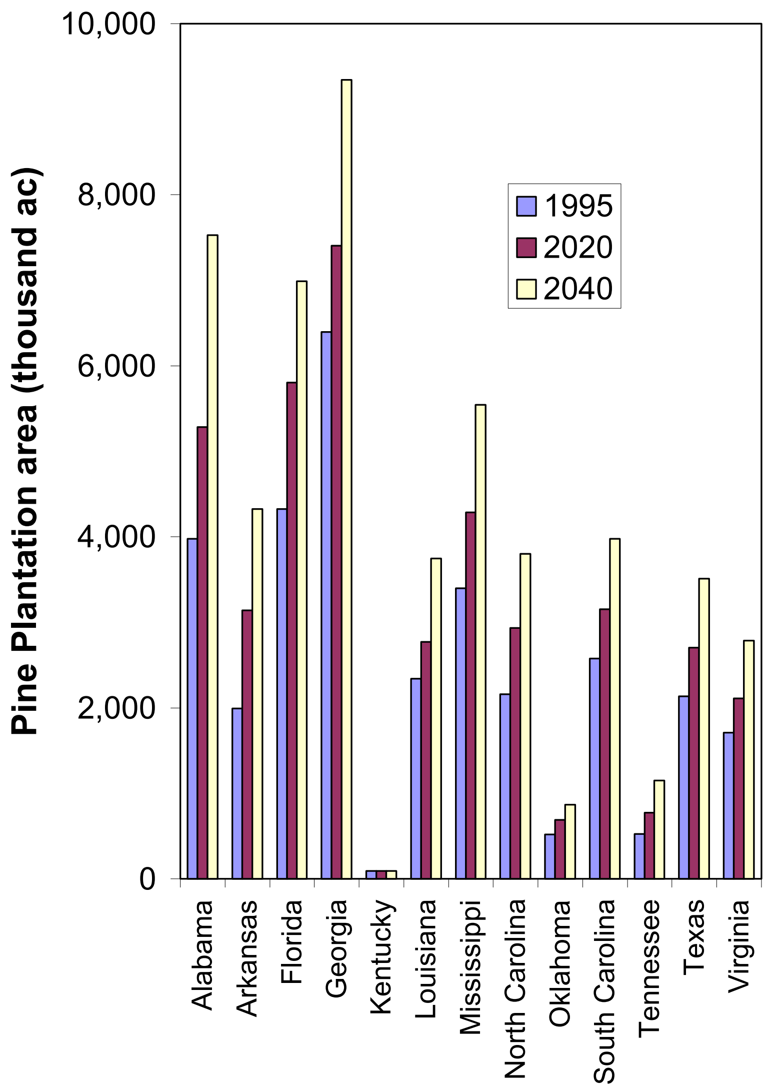

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Figure 22--Pine plantation area by ecoregion, 1995, 2020, and 2040.

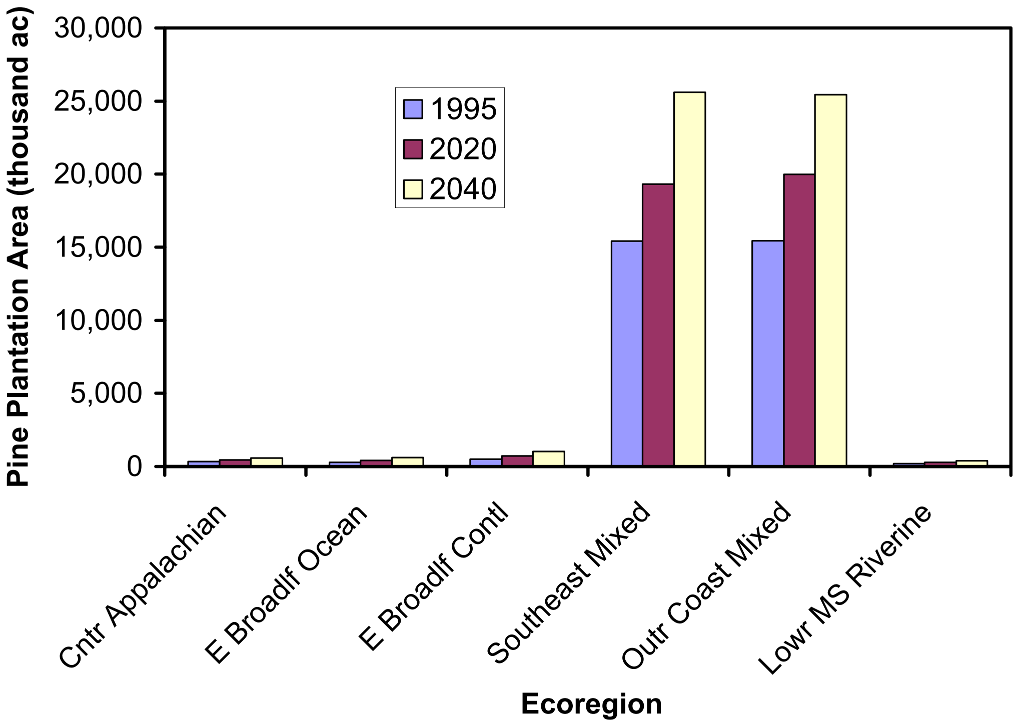

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Figure 23--Natural forest management type (natural pine, oak-pine, upland hardwood, bottomland hardwood) area by state in the South for 1995, 2020, and 2040, as projected by SRTS, under the IH (Base Case) scenario, with inelastic demand and a high pine plantation growth rate increase.

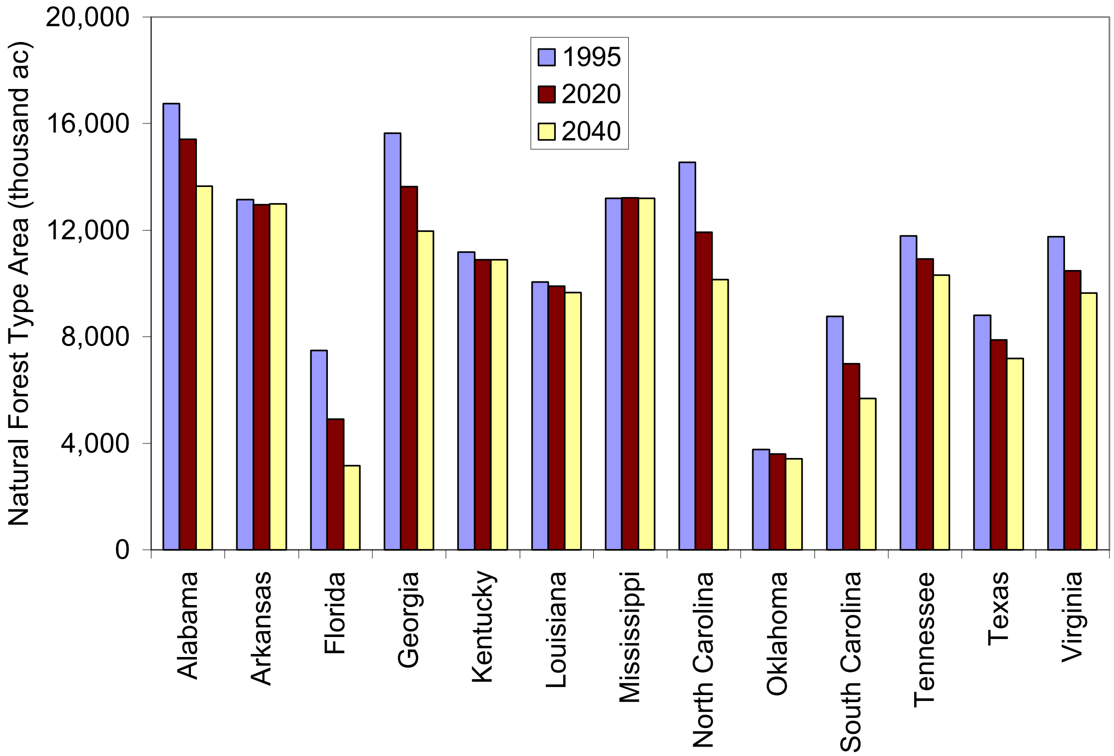

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Figure 24--Subregional Timber Supply Model projections of softwood timber growth and removals volumes (bcf), 1995-2040, under the IH (Base Case) assumptions of inelastic timber demand and high plantation volume growth rates.

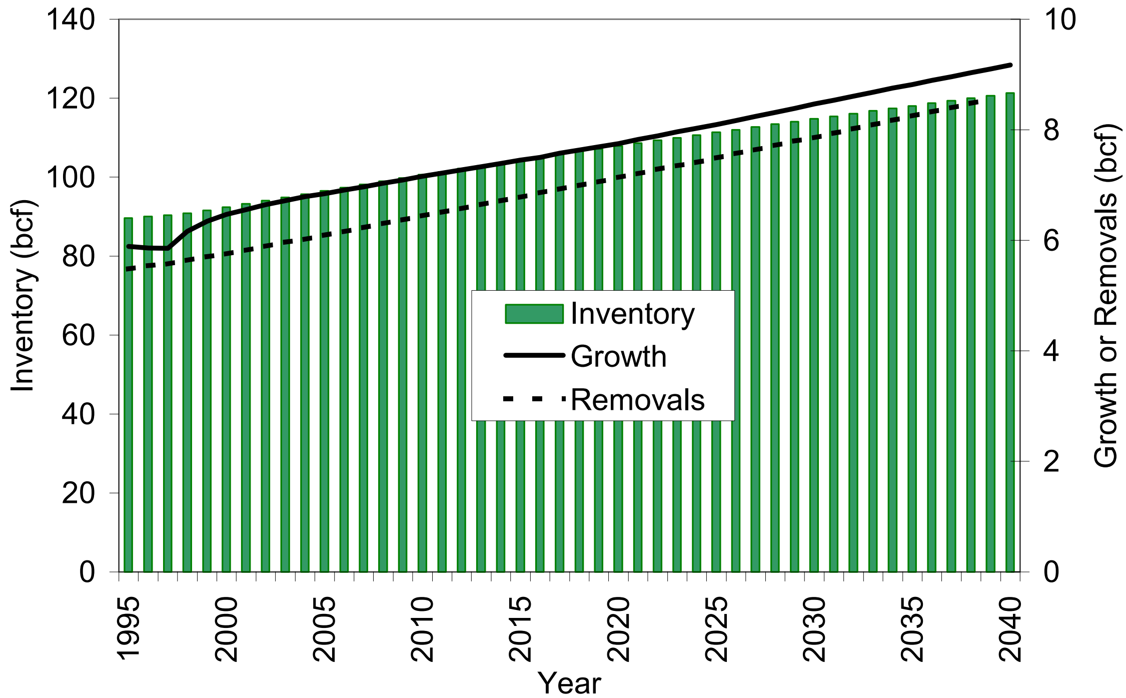

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Figure 25--Subregional Timber Supply Model projections of softwood timber growth and removals volumes (bcf), 1995-2040, under the IL assumptions of inelastic timber demand and low plantation volume growth rates.

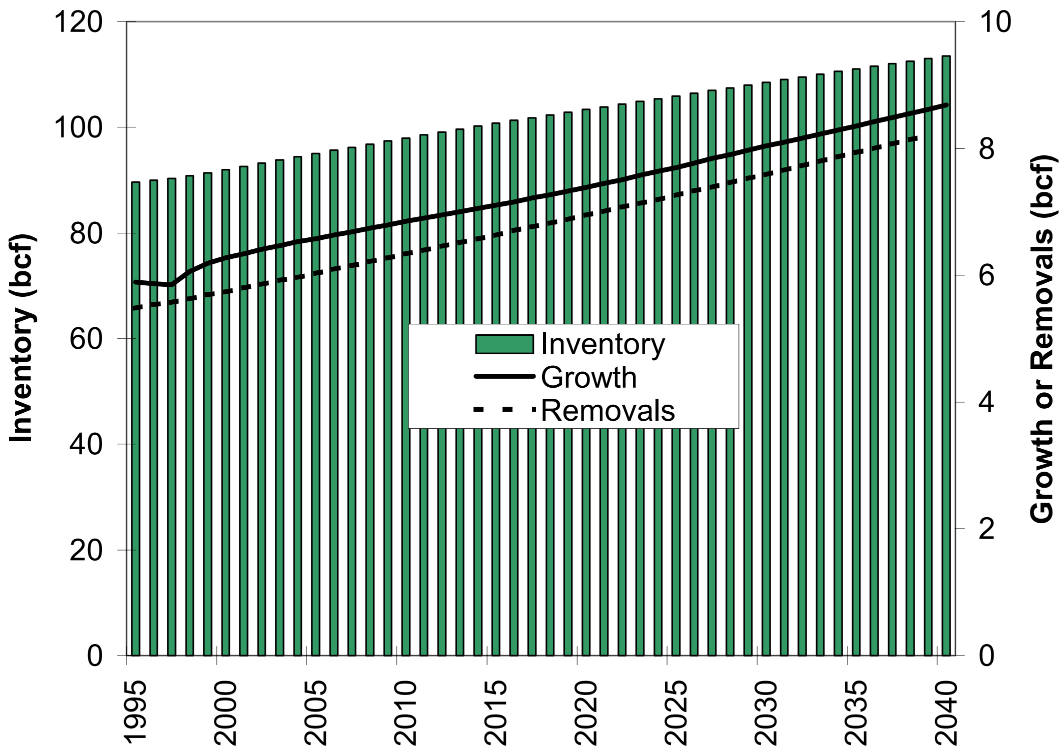

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Figure 26--Subregional Timber Supply Model projections of softwood timber growth and removals volumes (bcf), 1995-2040, under the EH assumptions of elastic timber demand and high plantation volume growth rates.

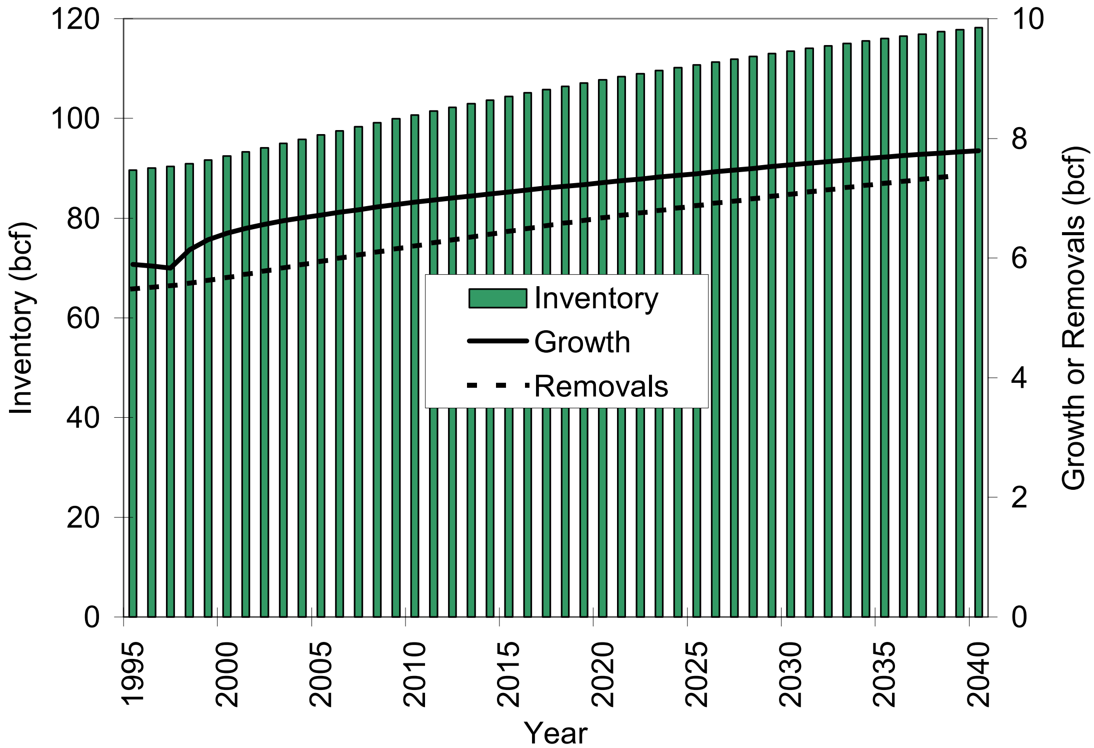

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Figure 27--Subregional Timber Supply Model projections of softwood timber growth and removals volumes (bcf), 1995-2040, under the EL assumptions of elastic timber demand and low plantation volume growth rates.

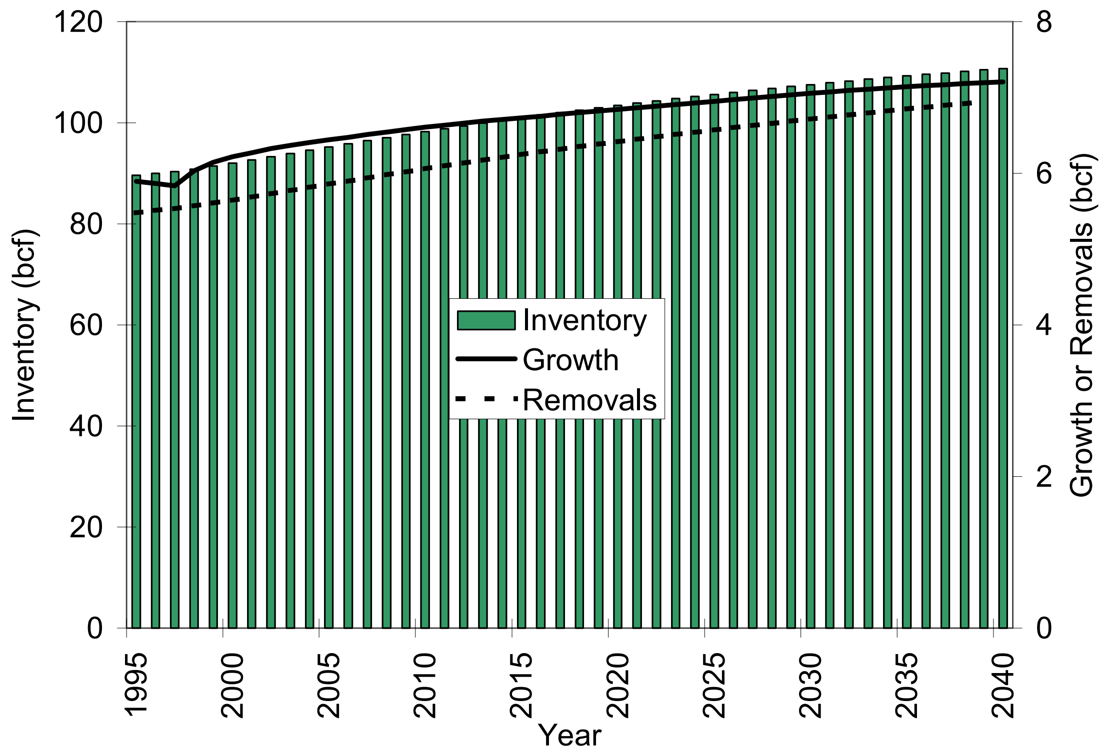

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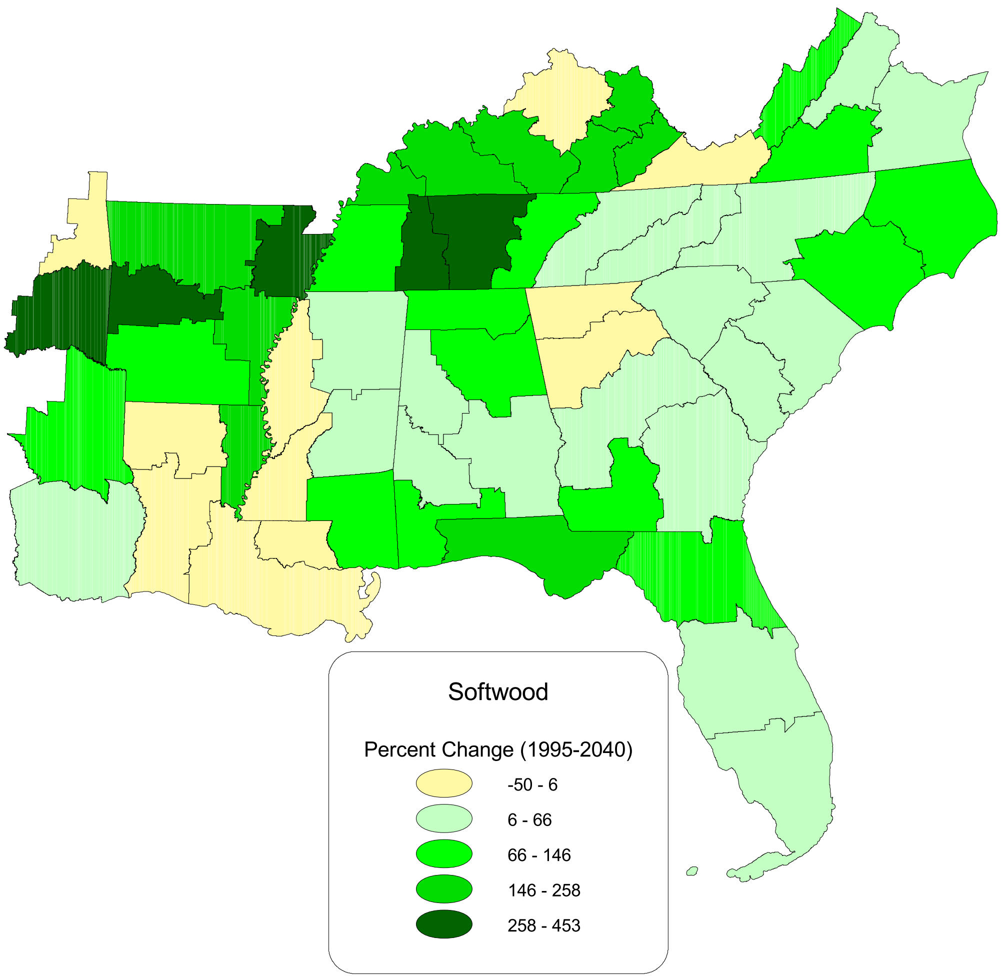
Figure 28--Percentage (A) and absolute (B) changes in annual softwood harvest levels, 1995-2040, as projected by the Subregional Timber Supply Model projections, by FIA Survey, under the IH (Base Case) assumptions of inelastic timber demand and high plantation volume growth rates.

A



B

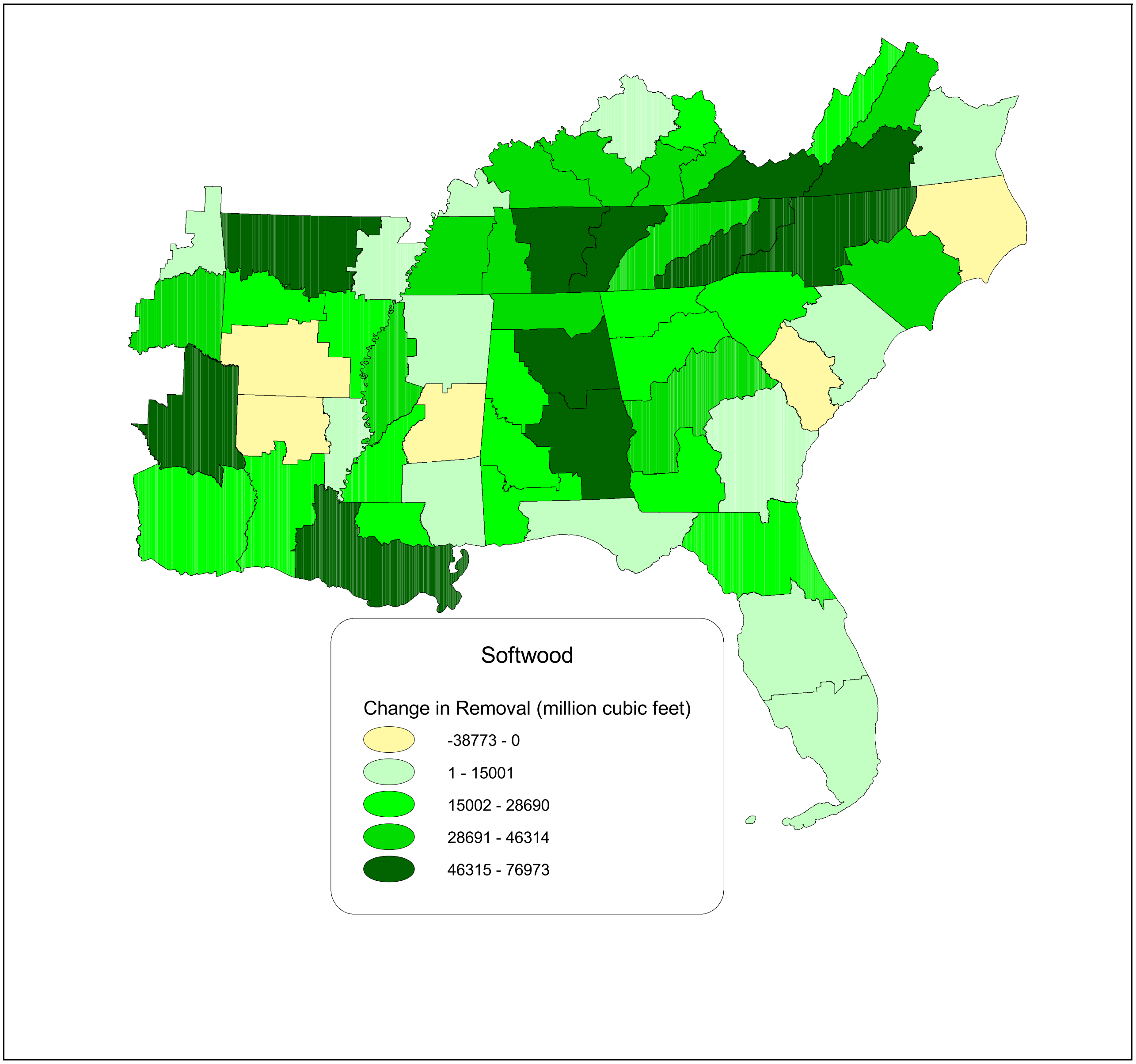


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Figure 29--Subregional Timber Supply Model projections of hardwood timber growth and removals volumes (bcf), 1995-2040, under the IH (Base Case) scenario assumptions of inelastic demand and high plantation volume growth rates.

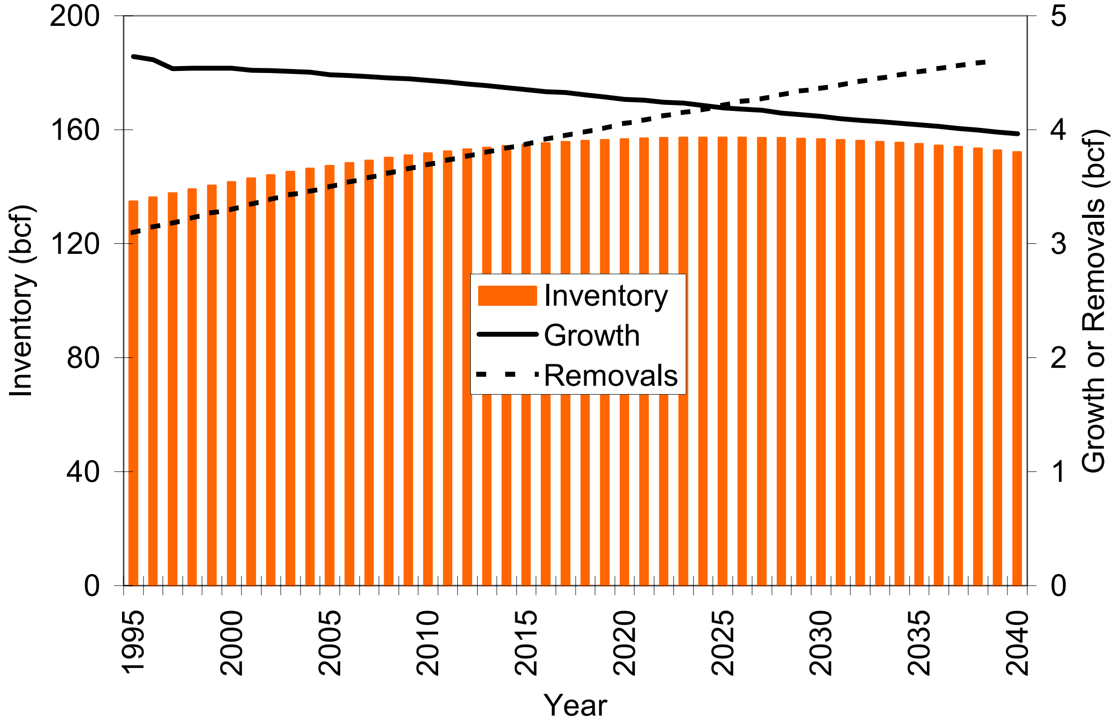

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Figure 30--Subregional Timber Supply Model projections of hardwood timber growth and removals volumes (bcf), 1995-2040, under the IL scenario assumptions of inelastic demand and low plantation volume growth rates.

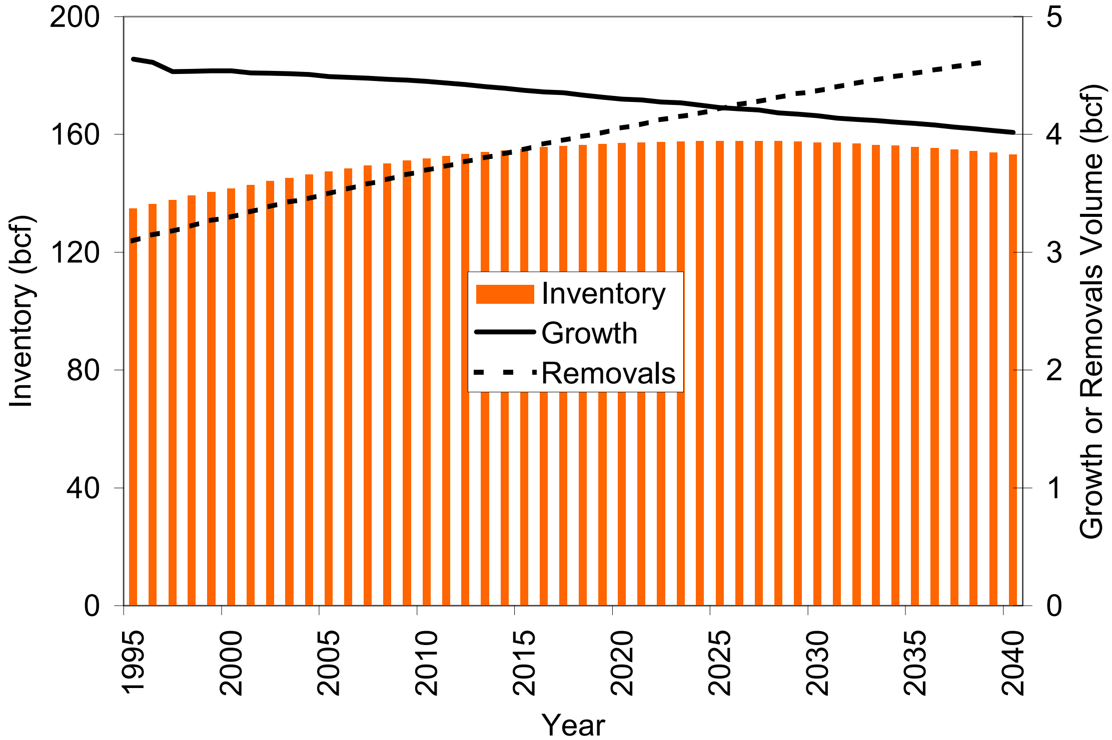

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Figure 31--Subregional Timber Supply Model projections of hardwood timber growth and removals volumes (bcf), 1995-2040, under the EH scenario assumptions of elastic demand and high plantation volume growth rates.

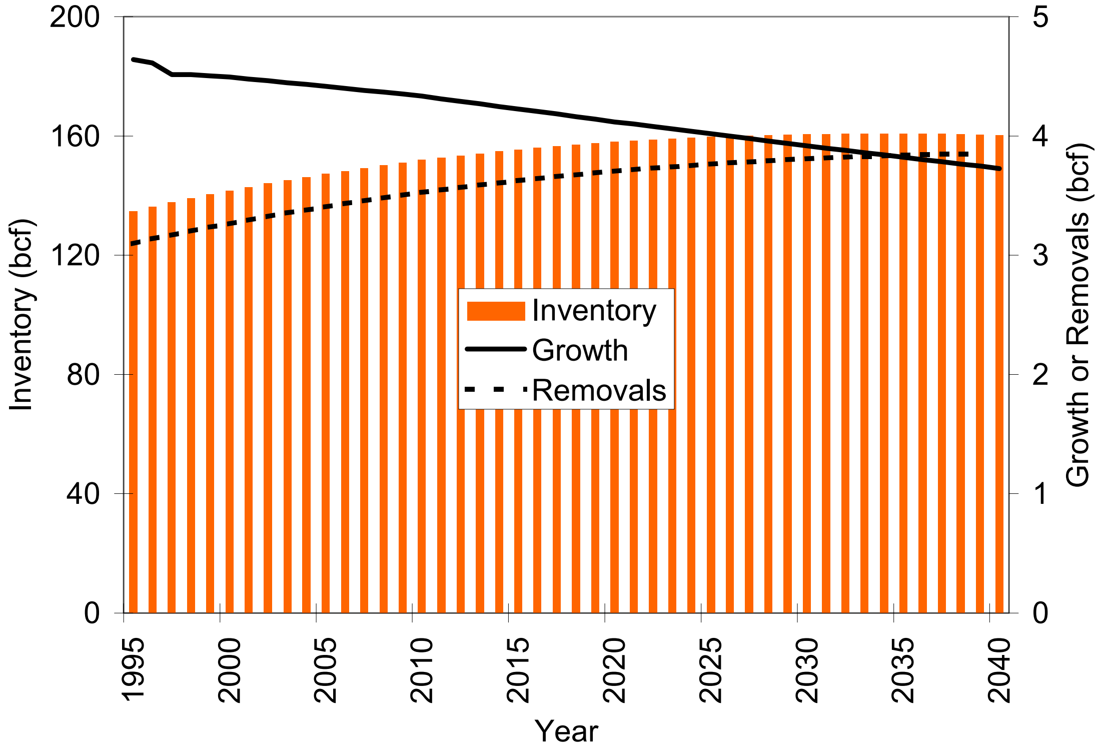

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Figure 32--Subregional Timber Supply Model projections of hardwood timber growth and removals volumes (bcf), 1995-2040, under the EL scenario assumptions of elastic demand and low plantation volume growth rates.

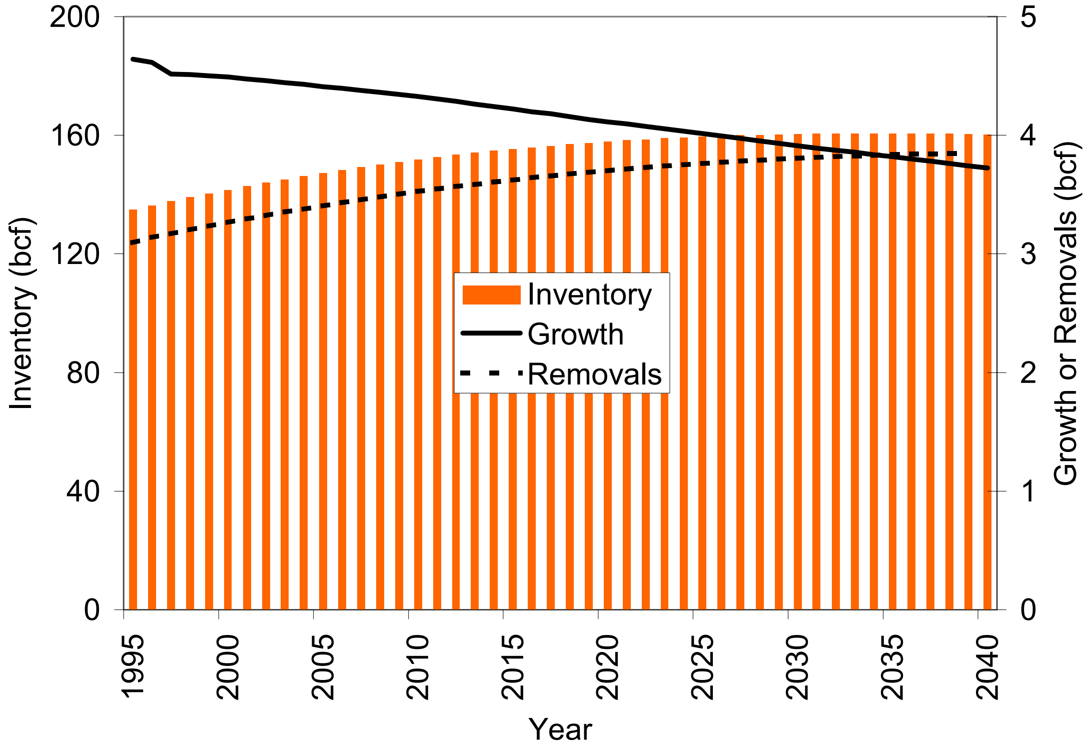

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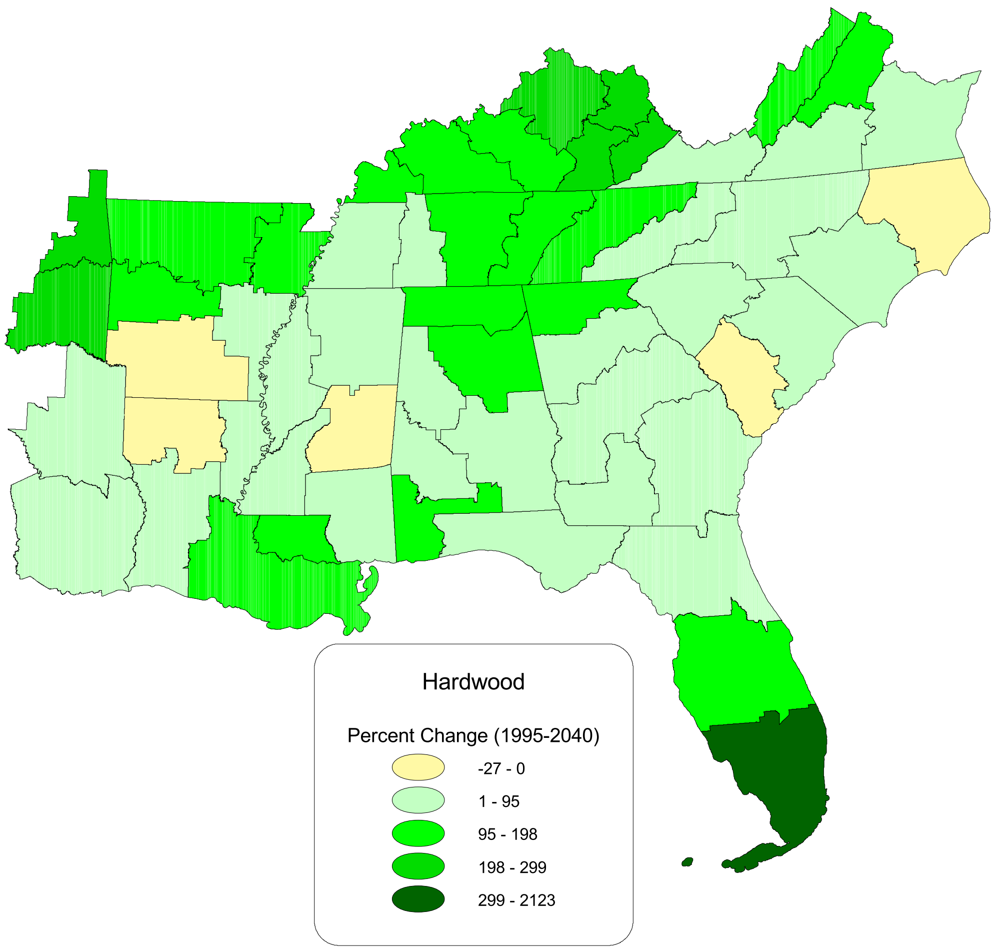
Figure 33--Percentage (A) and absolute (B) changes in annual hardwood harvest levels, 1995-2040, as projected by the Subregional Timber Supply Model projections, by FIA Survey Unit under IH (Base Case) assumptions of inelastic demand and high plantation volume growth rates.



A

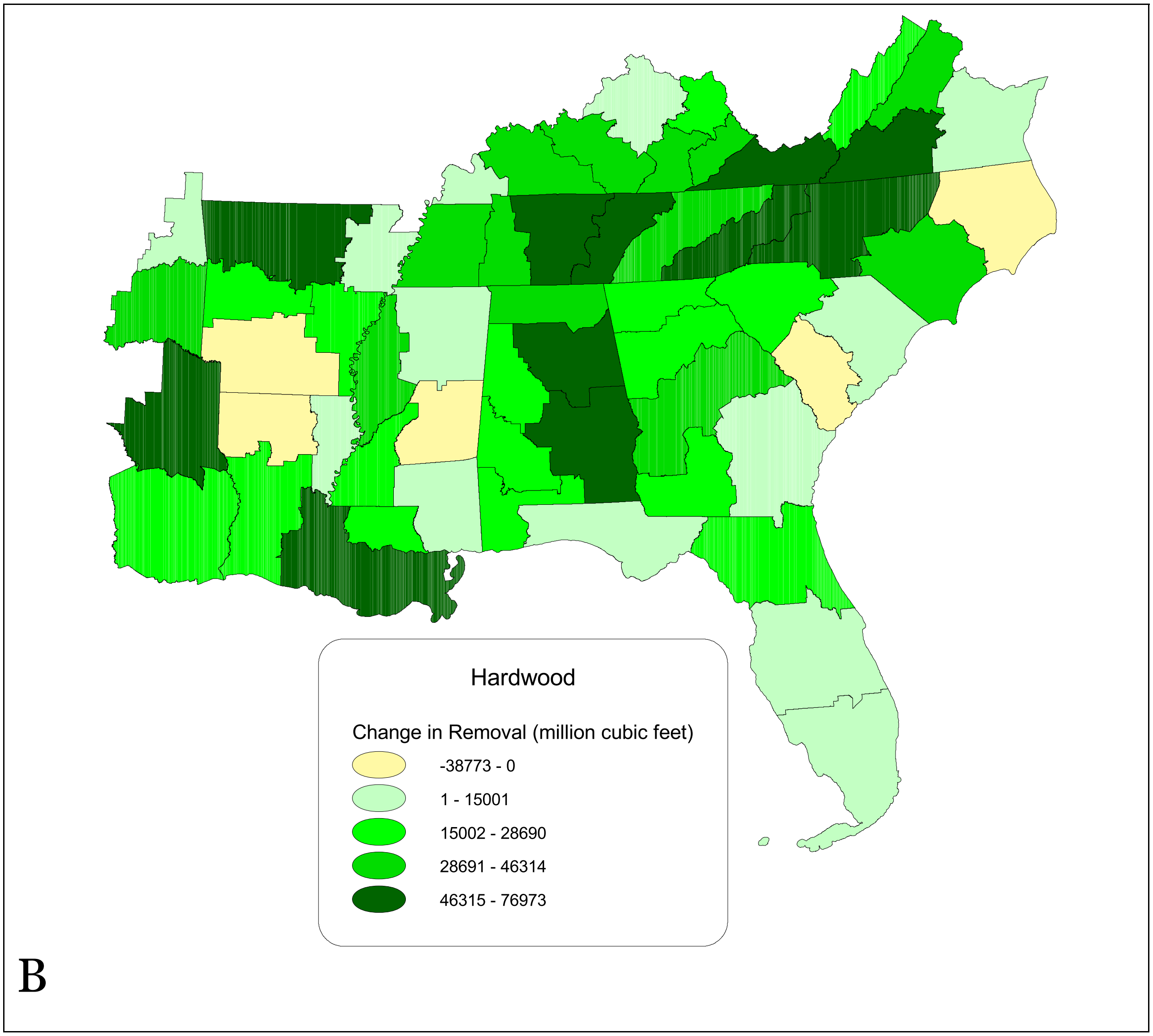


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Figure 34--Subregional Timber Supply Model projections of total timber growth and removals volumes (bcf), by owner (where NIPF stands for nonindustrial private forestland), 1995-2040, under the IH (Base Case) assumptions of inelastic demand and high plantation volume growth rates.

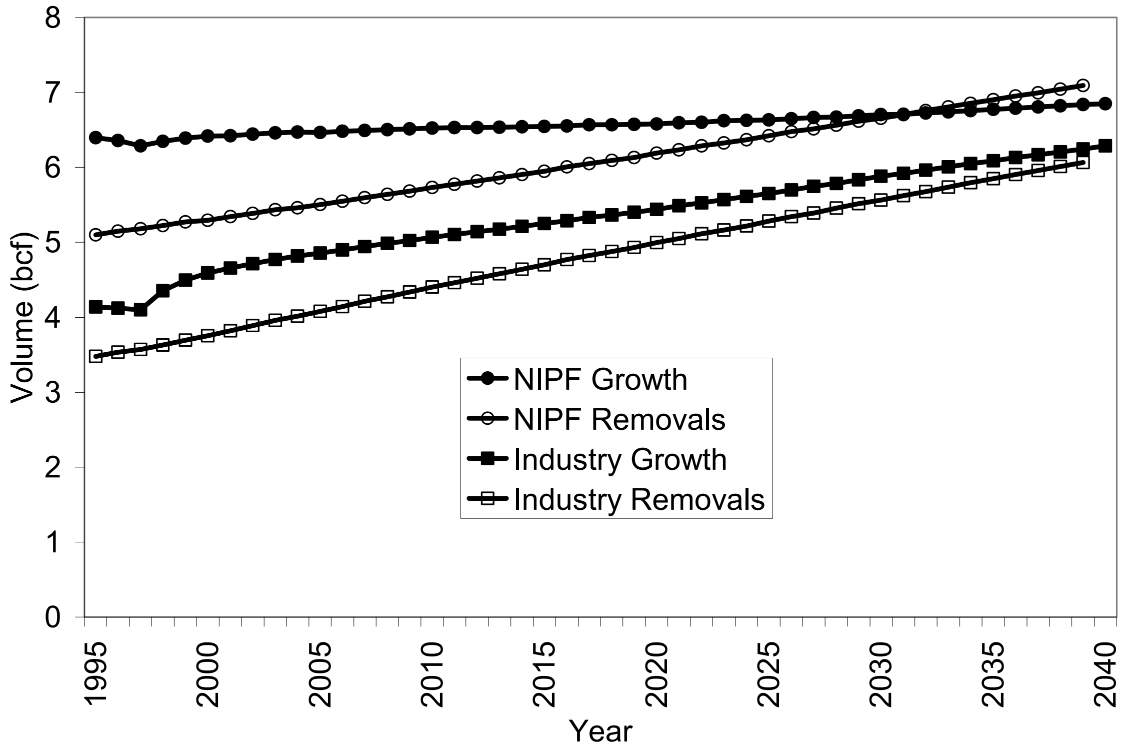

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Figure 35--Subregional Timber Supply Model projections of total timber growth and removals volumes (bcf), by owner (where NIPF stands for nonindustrial private forestland), 1995-2040, under the IL assumptions of inelastic demand and low plantation volume growth rates.

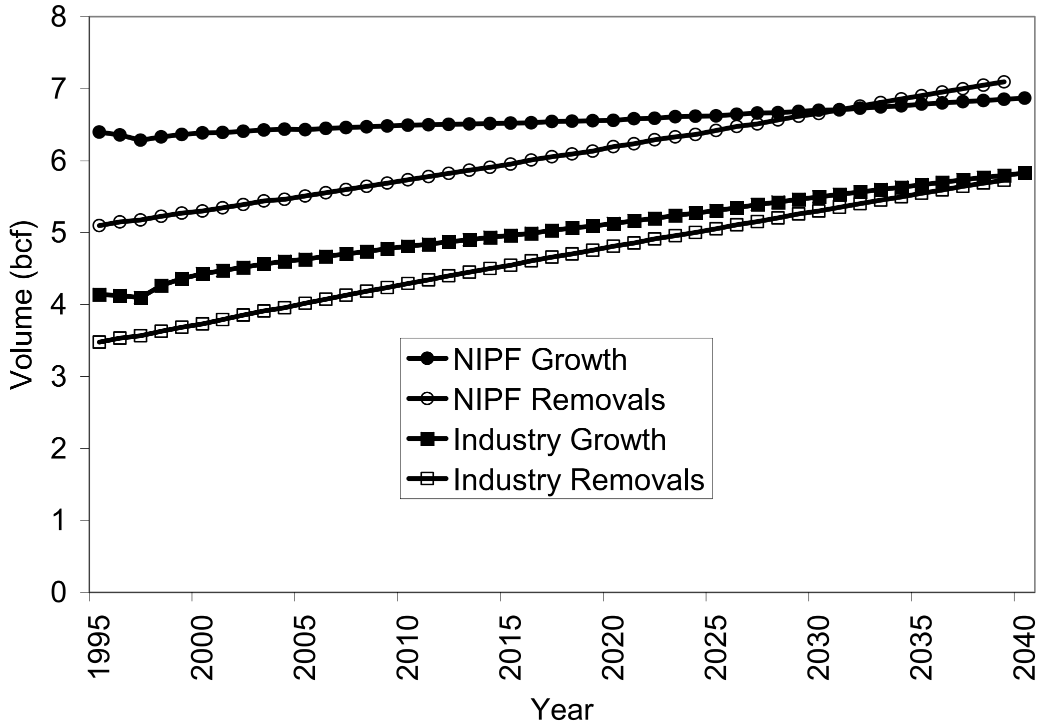

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Figure 36--Subregional Timber Supply Model projections of total timber growth and removals volumes (bcf), by owner (where NIPF stands for nonindustrial private forestland), 1995-2040, under the EH assumptions of elastic demand and high plantation volume growth rates.

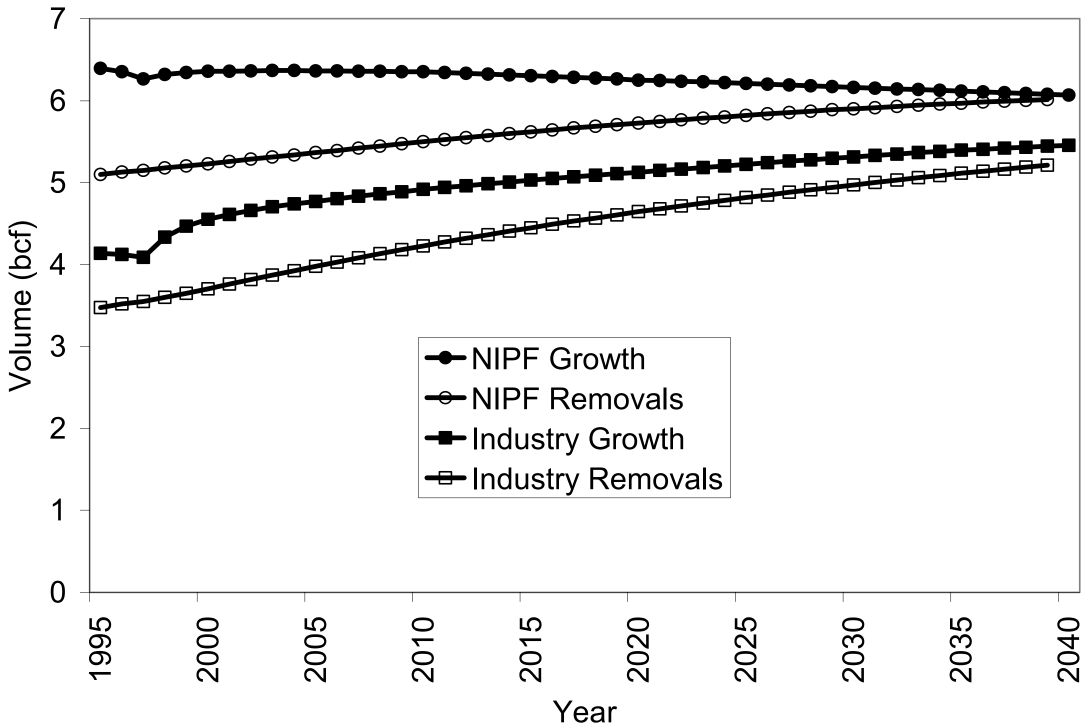

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Figure 37--Subregional Timber Supply Model projections of total timber growth and removals volumes (bcf), by owner (where NIPF stands for nonindustrial private forestland), 1995-2040, under the EL assumptions of elastic demand and low plantation volume growth rates.

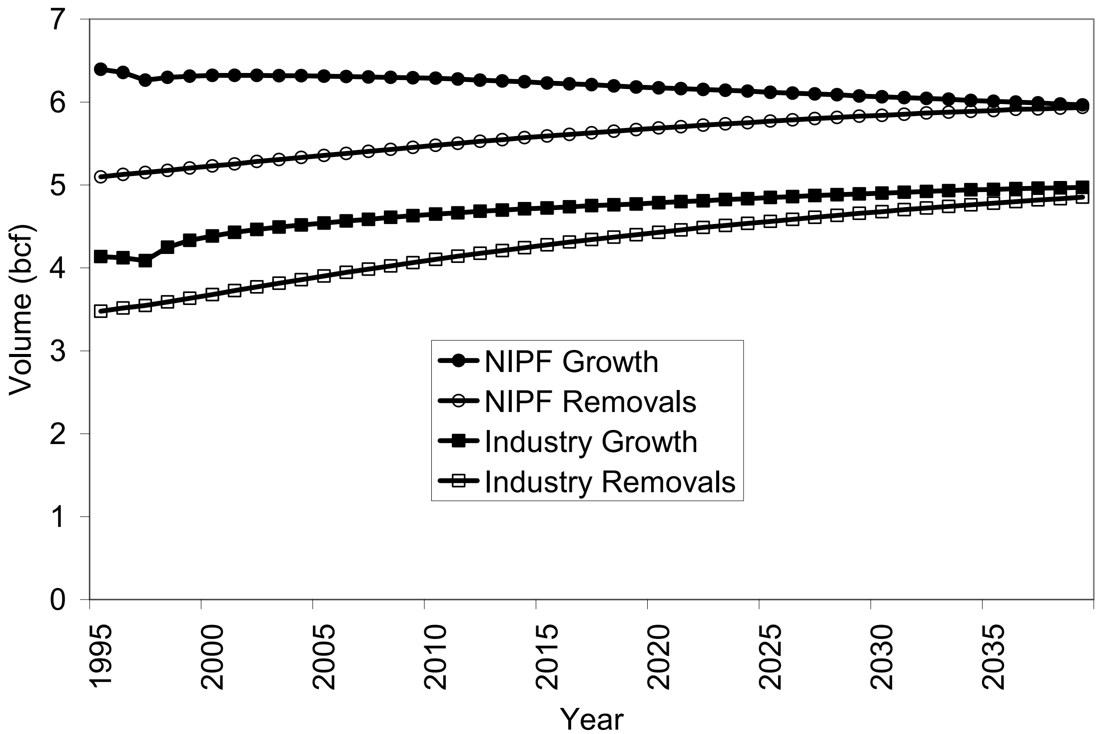

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Figure 38--SRTS projections of softwood age structure (volume by age class), southwide, 1995, 2020, and 2040, under the IH (Base Case) scenario of inelastic timber demand and high plantation growth rate increase.

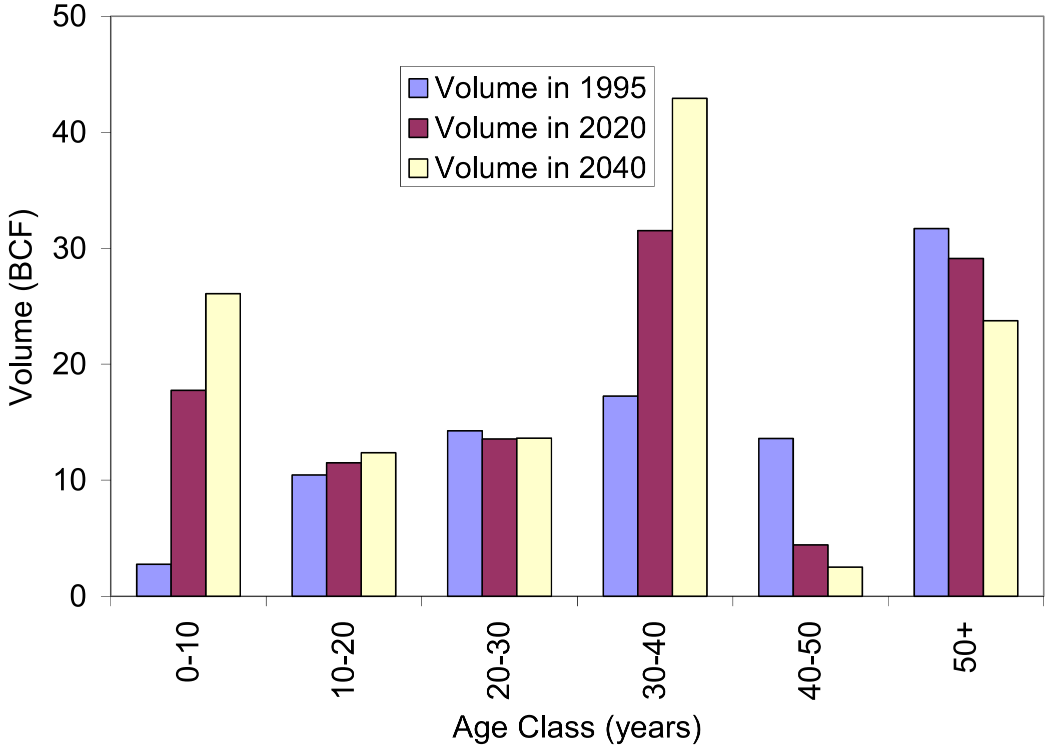

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Figure 39--SRTS projections of hardwood age structure (volume by age class), southwide, 1995, 2020, and 2040, under the IH (Base Case) scenario of inelastic timber demand and high plantation growth rate increase.

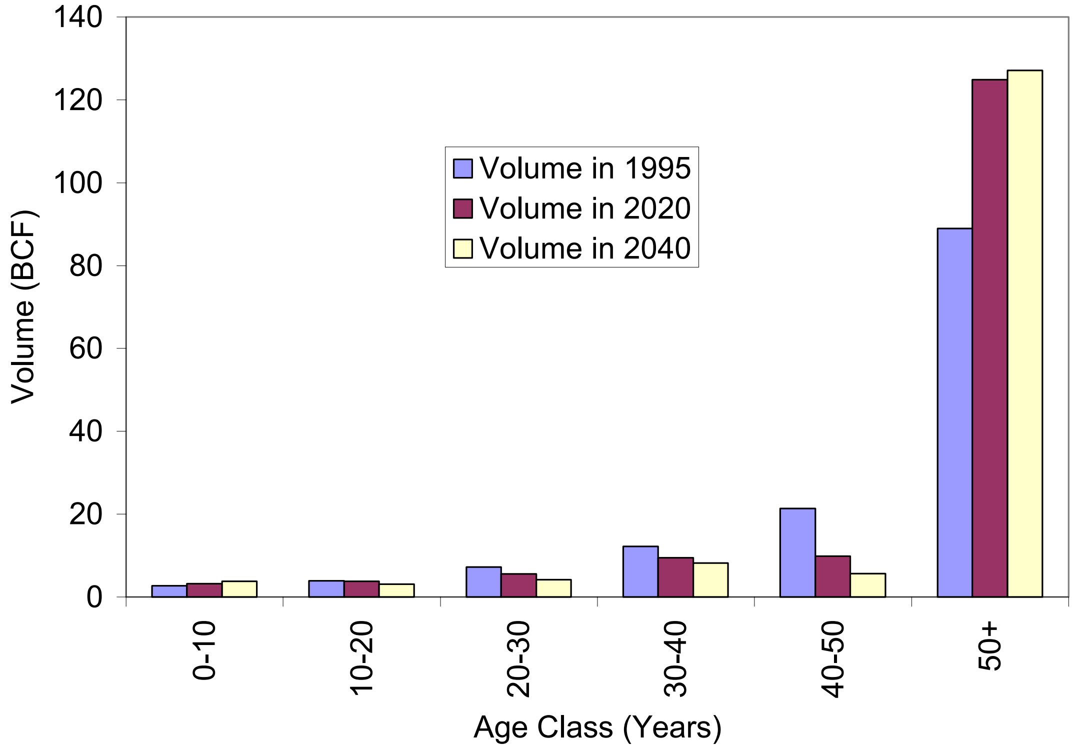

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Figure 40--SRTS projections of Alabama softwood and hardwood growth and removals volumes, 1995 to 2040, under the IH (Base Case) scenario of inelastic timber demand and high plantation growth rate increase.

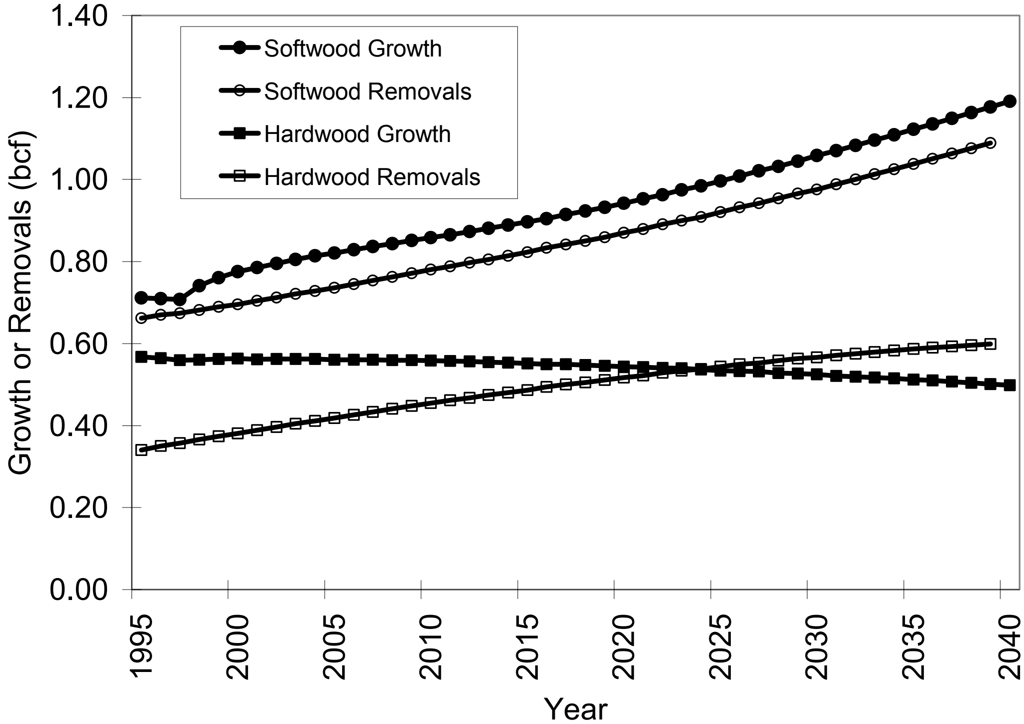

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Figure 41--SRTS projections of Arkansas softwood and hardwood growth and removals volumes, 1995 to 2040, under the IH (Base Case) scenario of inelastic timber demand and high plantation growth rate increase.

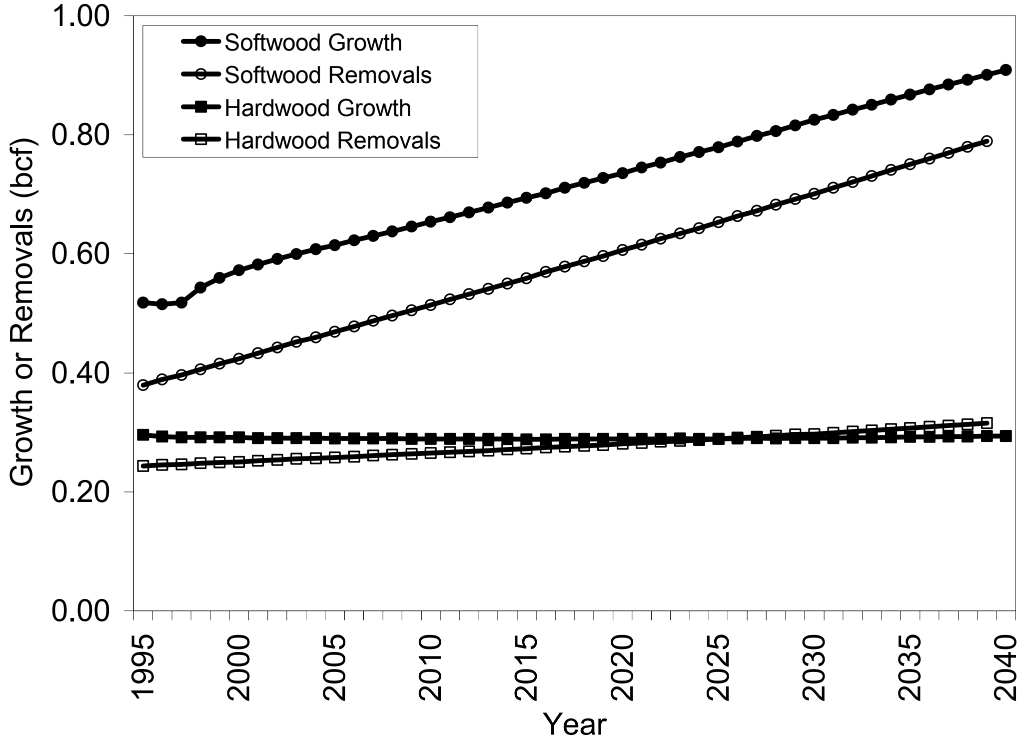

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Figure 42--SRTS projections of Florida softwood and hardwood growth and removals volumes, 1995 to 2040, under the IH (Base Case) scenario of inelastic timber demand and high plantation growth rate increase.

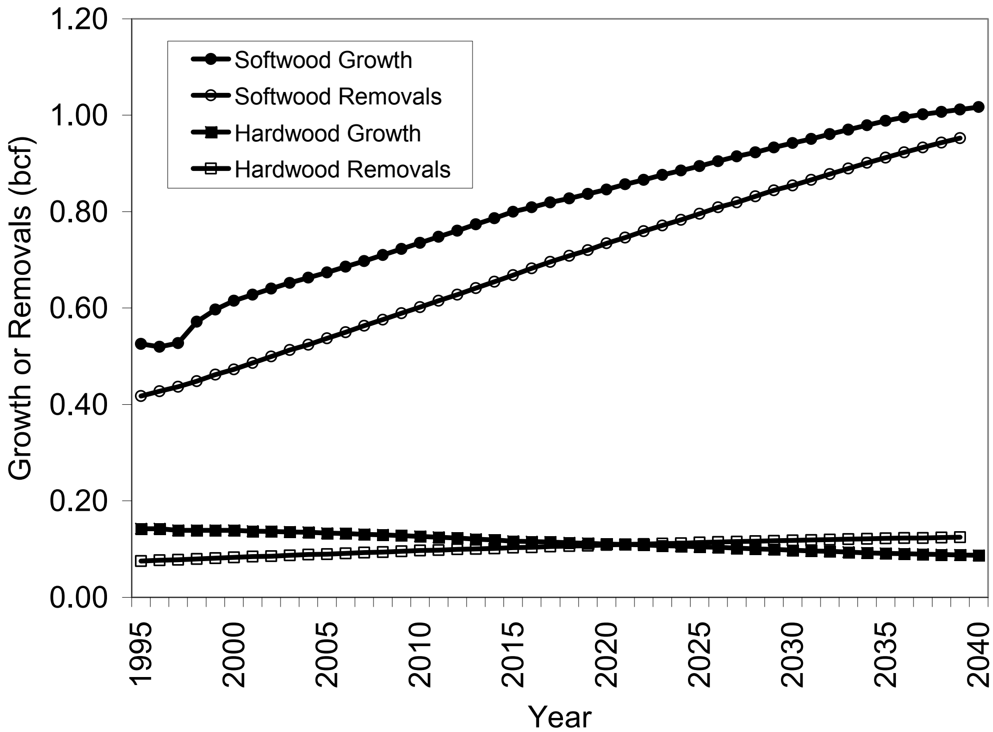

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Figure 43--SRTS projections of Georgia softwood and hardwood growth and removals volumes, 1995 to 2040, under the IH (Base Case) scenario of inelastic timber demand and high plantation growth rate increase.

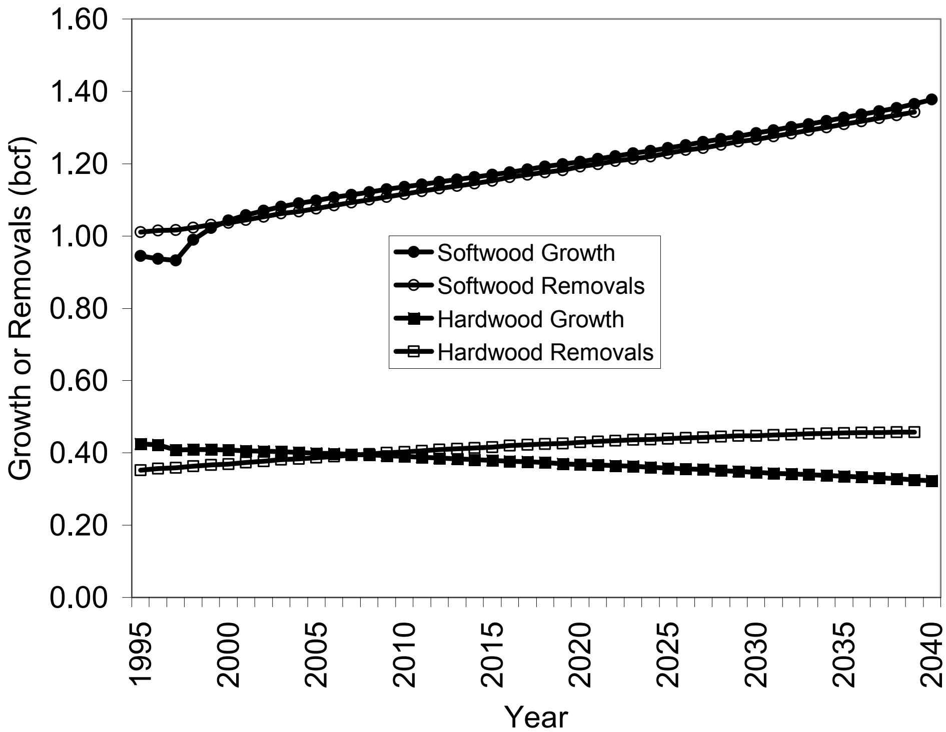

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Figure 44--SRTS projections of Kentucky softwood and hardwood growth and removals volumes, 1995 to 2040, under the IH (Base Case) scenario of inelastic timber demand and high plantation growth rate increase.

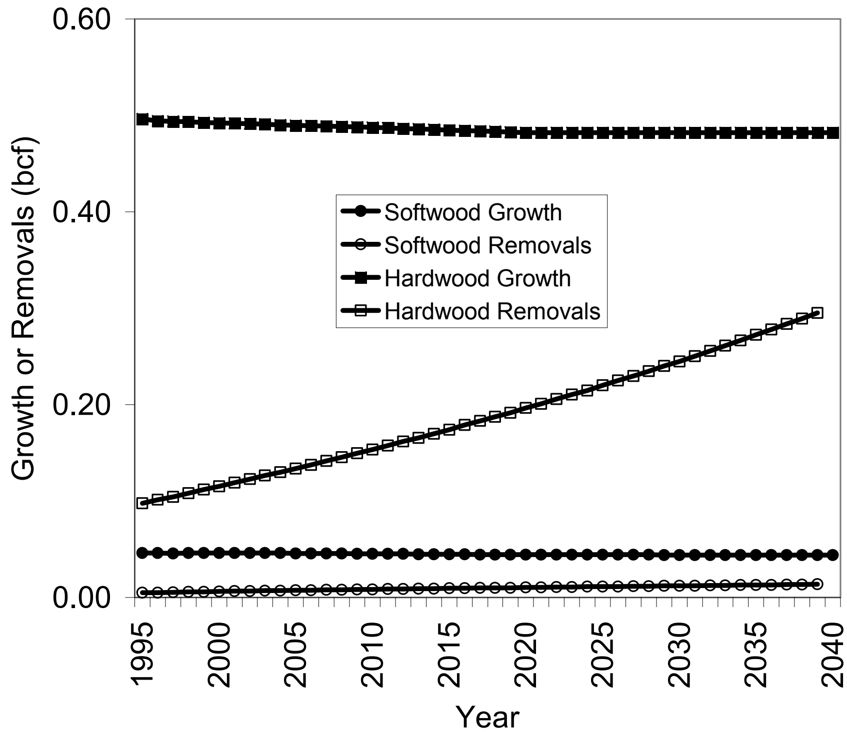

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Figure 45--SRTS projections of Louisiana softwood and hardwood growth and removals volumes, 1995 to 2040, under the IH (Base Case) scenario of inelastic timber demand and high plantation growth rate increase.

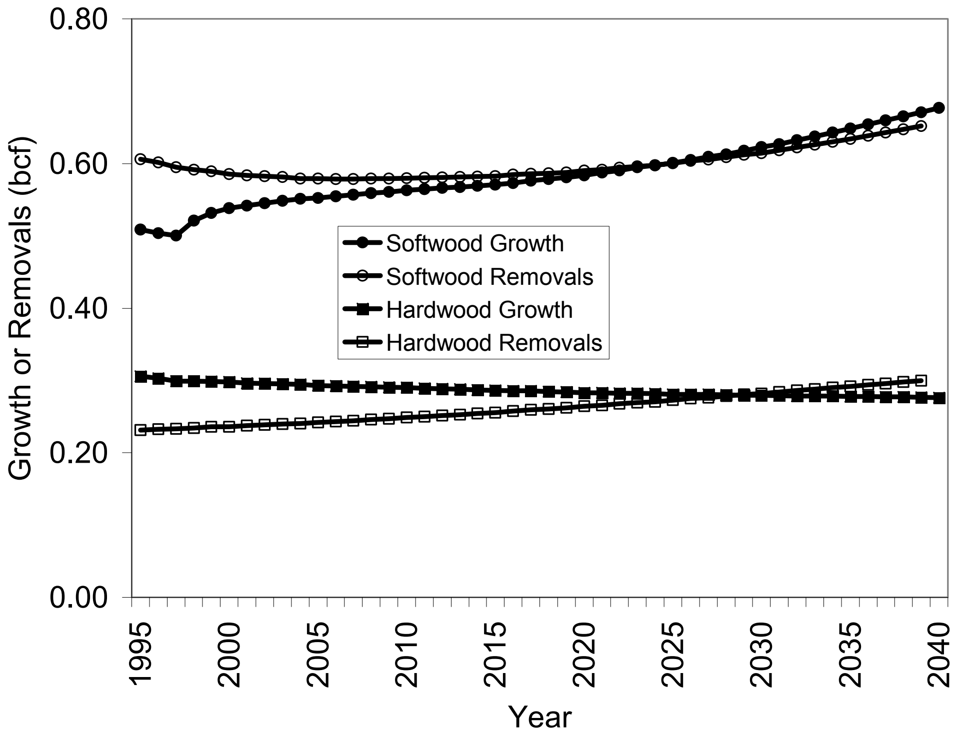

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Figure 46--SRTS projections of Mississippi softwood and hardwood growth and removals volumes, 1995 to 2040, under the IH (Base Case) scenario of inelastic timber demand and high plantation growth rate increase.

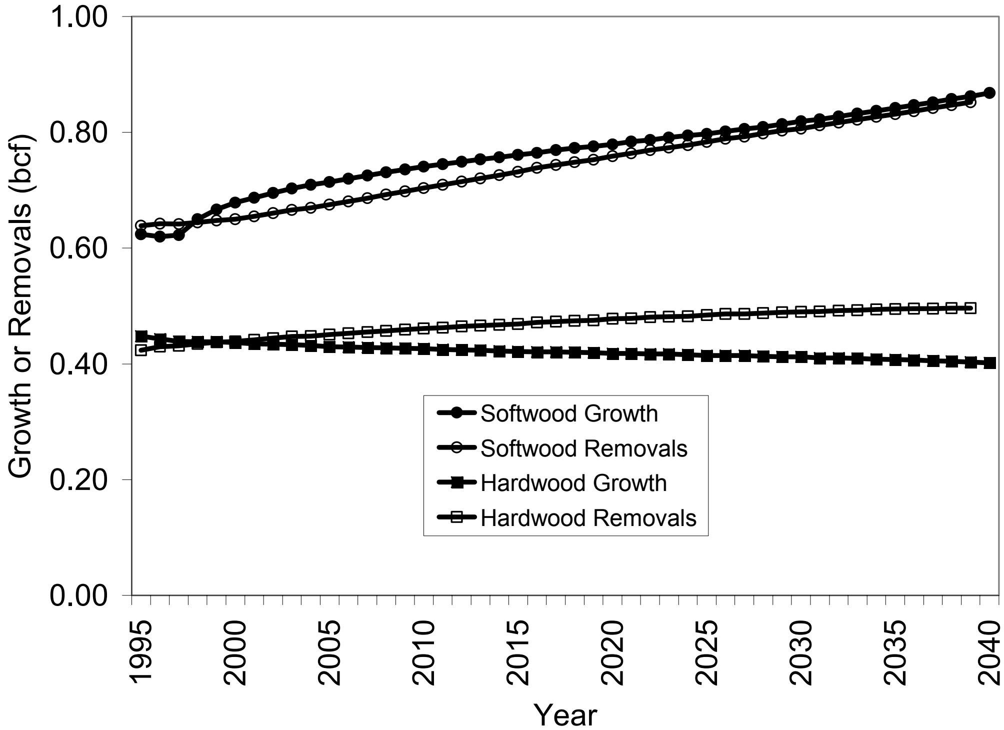

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Figure 47--SRTS projections of North Carolina softwood and hardwood growth and removals volumes, 1995 to 2040, under the IH (Base Case) scenario of inelastic timber demand and high plantation growth rate increase.

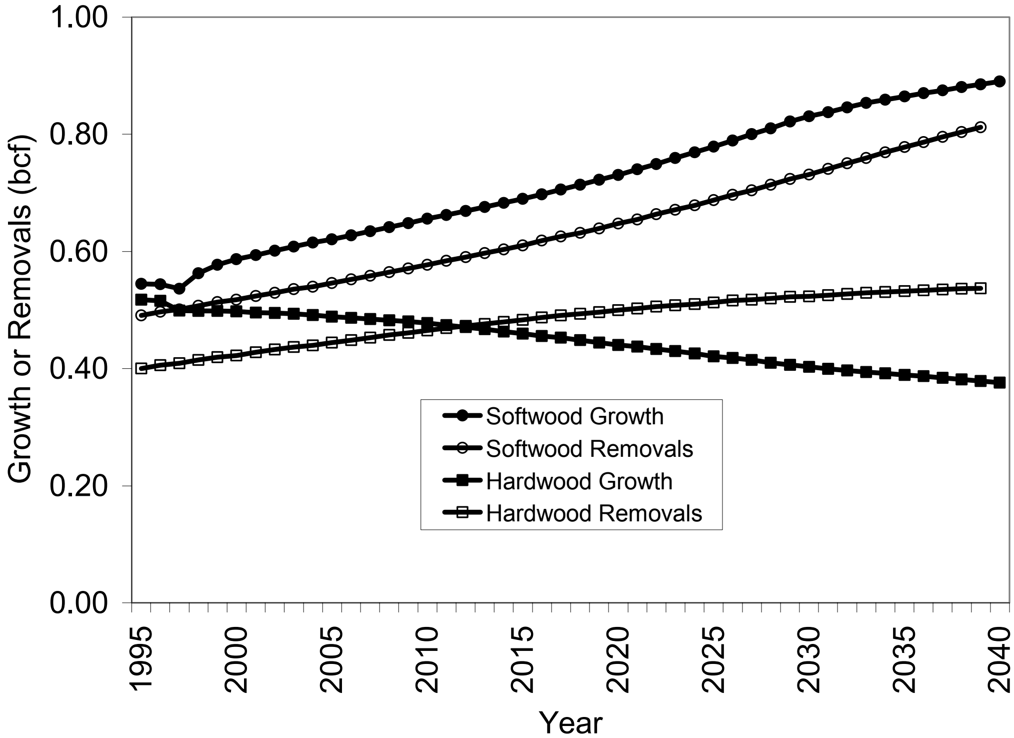

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Figure 48--SRTS projections of Oklahoma softwood and hardwood growth and removals volumes, 1995 to 2040, under the IH (Base Case) scenario of inelastic timber demand and high plantation growth rate increase.

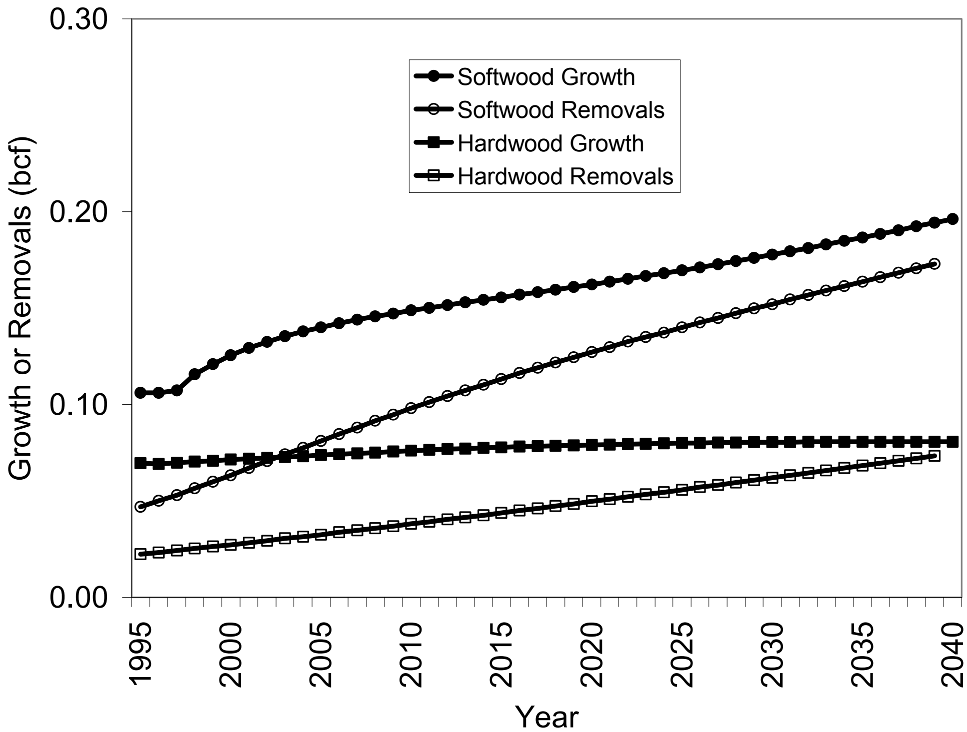

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Figure 49--SRTS projections of South Carolina softwood and hardwood growth and removals volumes, 1995 to 2040, under the IH (Base Case) scenario of inelastic timber demand and high plantation growth rate increase.

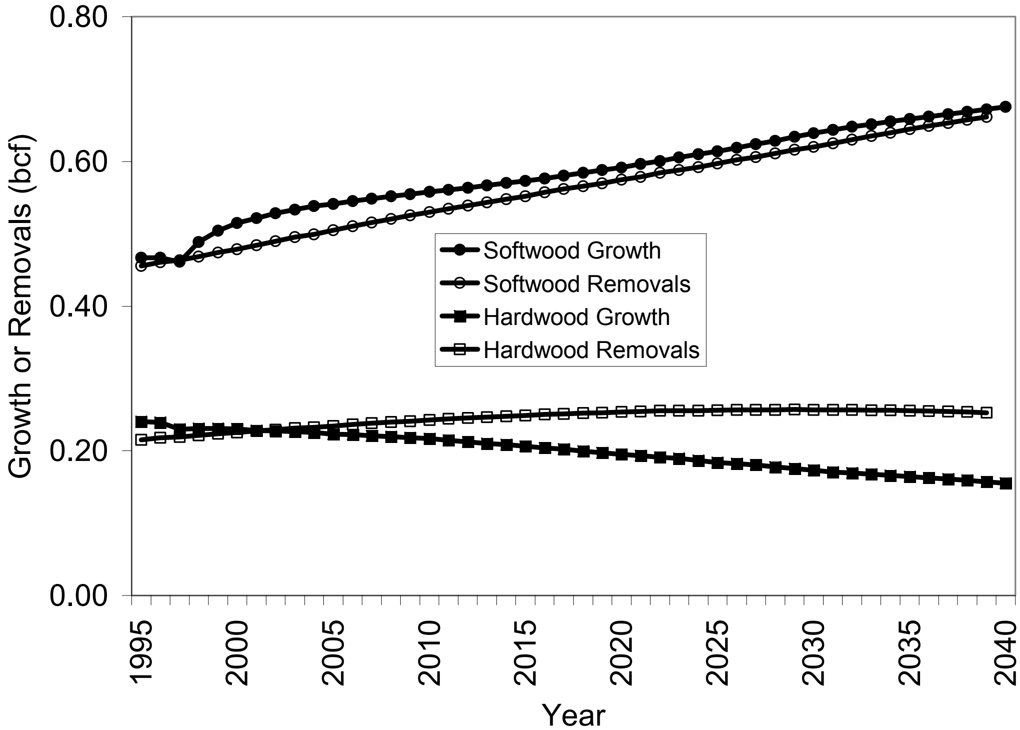

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Figure 50--SRTS projections of Tennessee softwood and hardwood growth and removals volumes, 1995 to 2040, under the IH (Base Case) scenario of inelastic timber demand and high plantation growth rate increase.

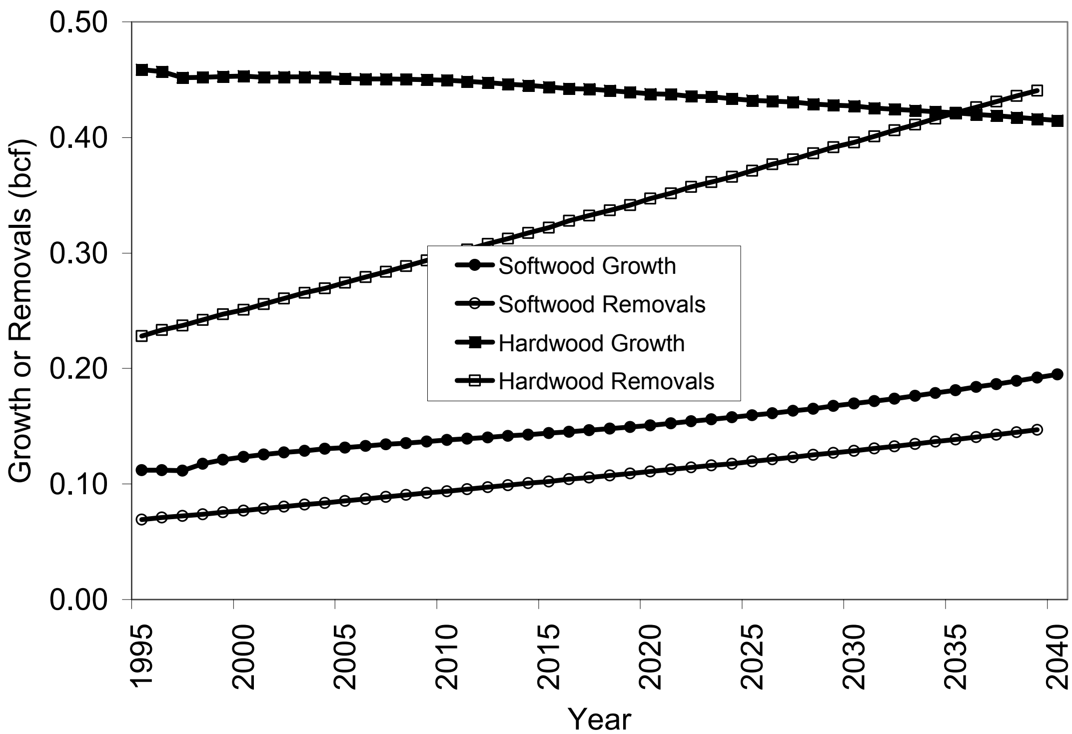

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Figure 51--SRTS projections of Texas softwood and hardwood growth and removals volumes, 1995 to 2040, under the IH (Base Case) scenario of inelastic timber demand and high plantation growth rate increase.

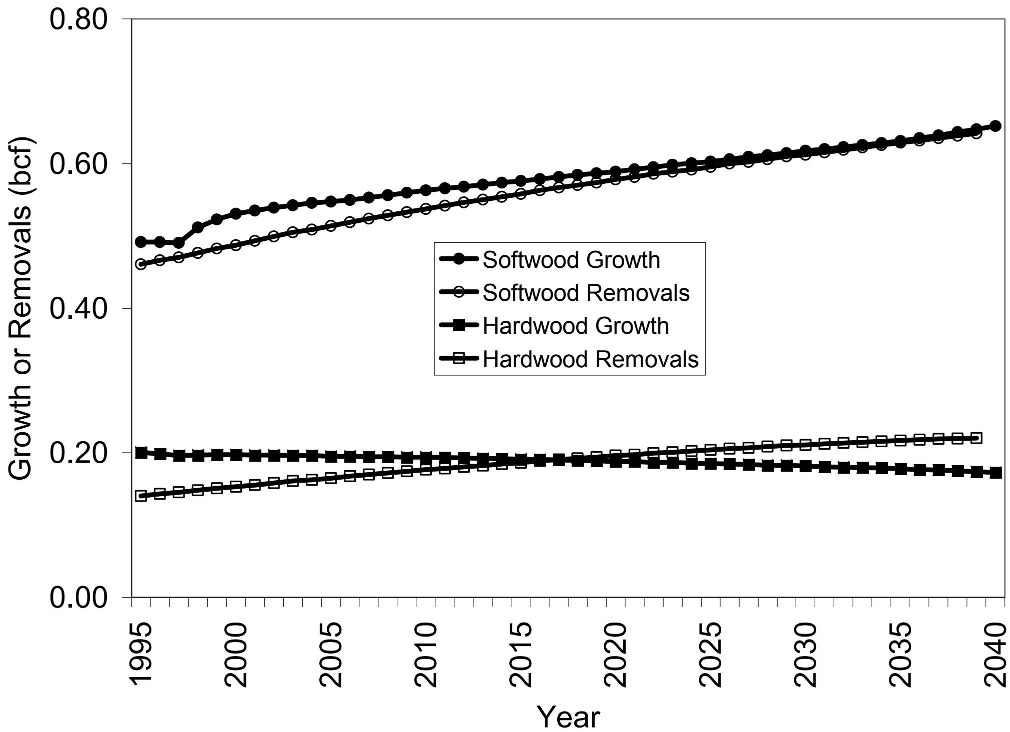

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Figure 52--SRTS projections of Virginia softwood and hardwood growth and removals volumes, 1995 to 2040, under the IH (Base Case) scenario of inelastic timber demand and high plantation growth rate increase.

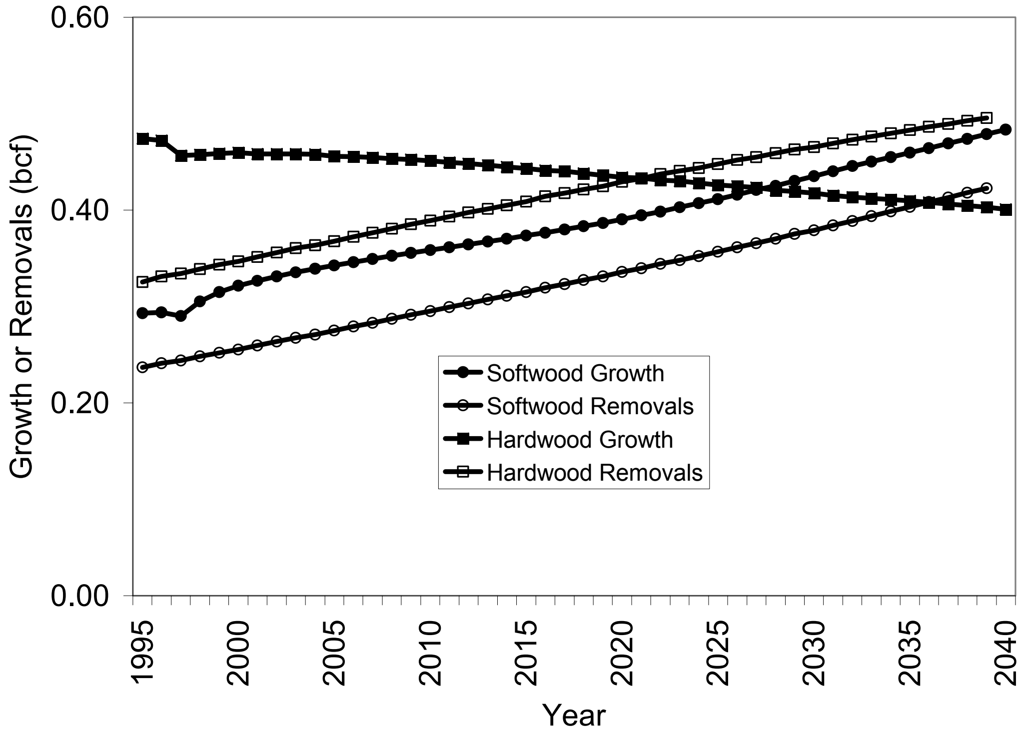

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Figure 53--Subregional Timber Supply Model projections of softwood timber prices, 1995-2039, under all scenarios.

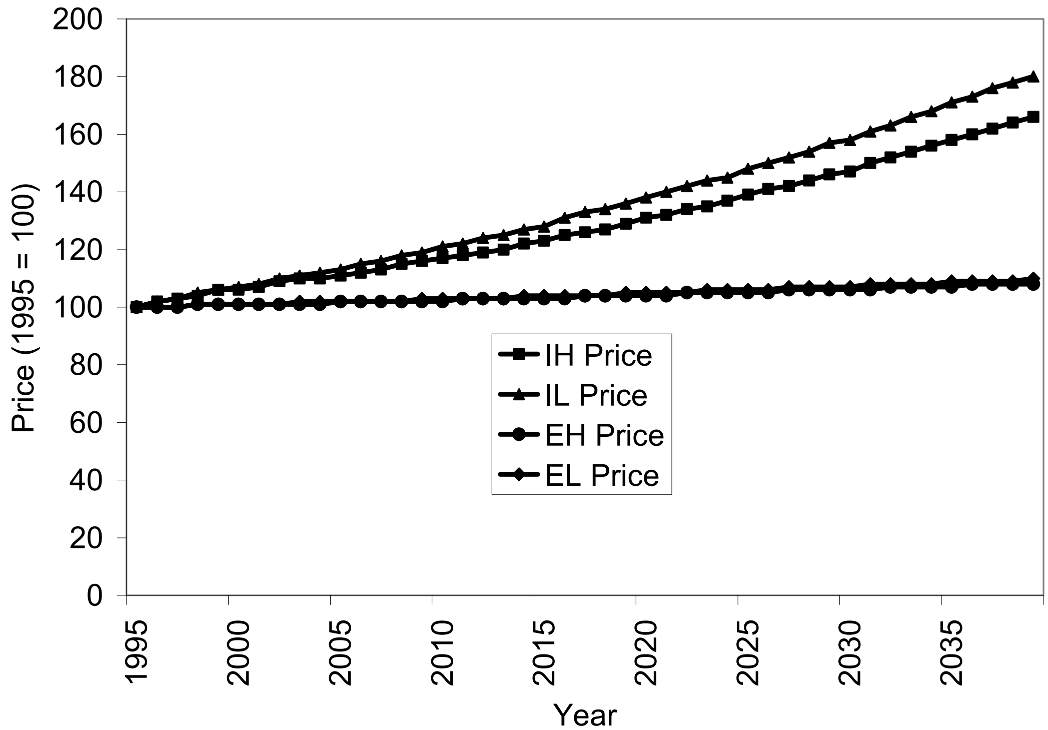

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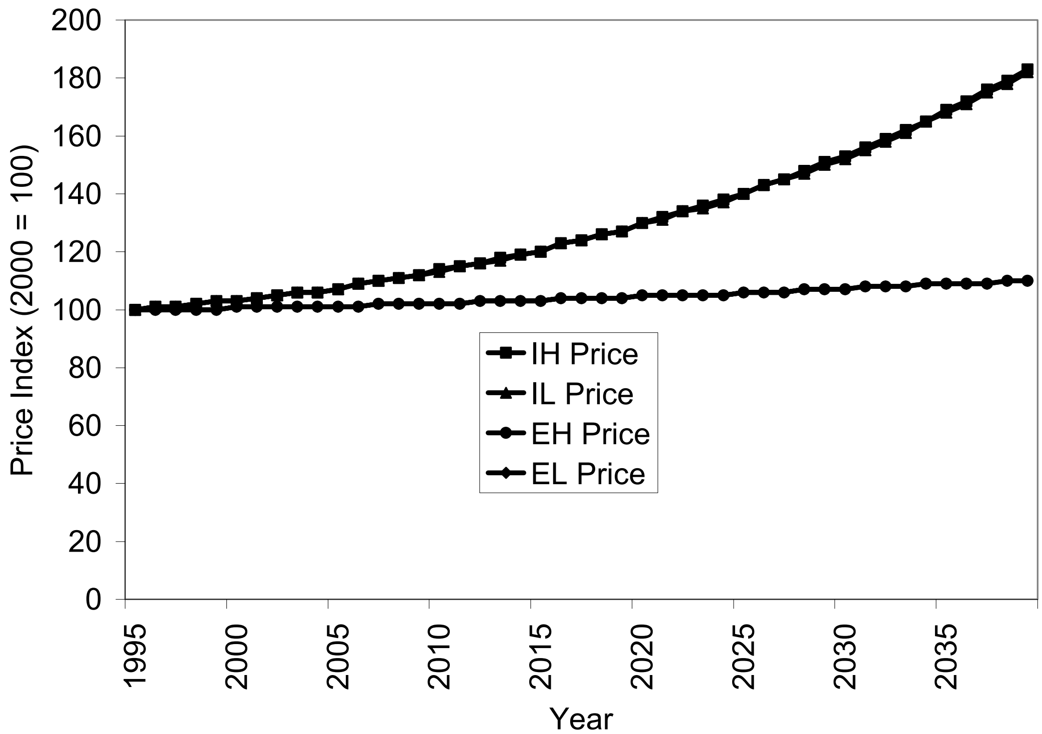
Figure 54--Subregional Timber Supply Model projections of hardwood timber prices, 1995-2039, under all scenarios.



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